CORPS OF ENGINEERS
U. S. ARMY

REPORT OF CONSTRUCTION

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

TECHNICAL REPORT NO. 4-7
MARCH 1957

PREPARED BY

THE RIGID PAVEMENT LABORATORY OF
THE OHIO RIVER DIVISION LABORATORIES
MARIEMONT, OHIO

FOR

OFFICE OF THE CHIEF OF ENGINEERS
AIRFIELDS BRANCH
ENGINEERING DIVISION
MILITARY CONSTRUCTION

Corps of Engineers

U. S. Army

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REPORT OF CONSTRUCTION

PART I - INTRODUCTION

1.01 AUTHORITY AND BACKGROUND:

The authority for initiating this investigation is contained in a letter from the Office, Chief of Engineers to the Division Engineer, Ohio River Division, Attention: Rigid Pavement Laboratory, dated 27 June 1955, Subject: "F. Y. 1956 Investigational Program for Development of Pavement Design Criteria for Channelized Traffic." As a result of the above letter, a design proposal was formulated by the Rigid Pavement Laboratory and presented to the Conferees at a Consultants meeting held at the Ohio River Division Laboratories 14 and 15 July 1955. This proposal consisted of three plain concrete items and four reinforced items for test. Changes suggested at the above conference resulted in increasing the number of reinforced items to six and building two tracks, one on a low quality subgrade and the other on a high quality subgrade.

The new proposal was presented on 21 July 1955 at a joint meeting in the Office, Chief of Engineers with personnel from Headquarters, U. S. Air Force. Formal authority for proceeding with the investigation is contained in letter from the Office, Chief of Engineers to the Division Engineer, Ohio River Division, Attention: Rigid Pavement Laboratory, dated 4 August 1955, Subject: "Accelerated Traffic Test for Development of Pavement Design Criteria for Channelized Traffic" and inclosure thereto.

1.02 PURPOSE:

The purpose of this investigation is to obtain data through the media of traffic tests which will:

a. Verify the interim criteria for the design and evaluation of rigid pavements subjected to channelized aircraft traffic.

b. Explore the effect of steel reinforcing on rigid airfield pavements subjected to a large number of loading cycles.

The purpose of this report is to provide a record of the design features, details of construction and physical properties of the subgrade and concrete. This report will serve as a guide in analyzing the results obtained by the traffic tests and accompanying auxiliary measurements.

1.03 SCOPE:

This report includes a description of the design features, details

of the methods employed in constructing the pavements, results of tests to determine the physical properties of the materials of construction, and details of the installation of the various measuring devices. A summary is included at the end of the report which gives the recommended values for use in analyzing the results of the traffic tests.

1.04 PLANS AND SPECIFICATIONS:

The plans and specifications were prepared by the District Engineer, U. S. Engineer Office, Huntington, West Virginia, in collaboration with the Ohio River Division Laboratories and incorporated the recommendations of the Office, Chief of Engineers, the Consultants on Airfield Pavements, and the Ohio River Division Laboratories. The specifications were prepared with the specific intention of setting requirements that would result in construction of uniform, good quality pavement, comparable to that of normal airfield construction. Minor deviations from the plans and specifications occurred during construction; however, these deviations did not adversely affect the intent of the specifications. During the grading operations it was discovered that required subgrade strengths could not be obtained, and a change order was prepared, increasing the original thickness of all plain concrete items by 1 inch. In addition, crushed gravel for the concrete was specified in lieu of

natural gravel; also some additional grading and resetting of forms was necessary. These three additions were the only exceptions to the original plans and specifications.

1.05 CONTRACT:

The construction contract was divided into three parts; other parts included construction of a prestressed overlay mat and a buckling slab model. A breakdown of the contract bid prices and actual quantities has been made, and only that information pertaining to the channelized test tracks is shown in this report.

The contract, DA-46-022-Eng-2239, was awarded to the W. L. Johnson Construction Company and Associates, Columbus, Ohio, at a bid price of $53, 378. 14. Construction was formally started on 29 November 1955 with a completion date of 28 January 1956. With the exception of sealing joints, the contract was accepted for beneficial occupancy on 10 January 1956. Weather conditions delayed sealing of joints until 7 February 1956; however, no liquidated damages were assessed the contractor since the contract had been accepted prior to expiration of the completion date. Final payment in the amount of $54, 070. 39 was made 20 February 1956. The final payment estimate showing contract prices and quantities, and actual quantities and

prices are shown in Table A below. The construction was performed under the direction of the District Engineer, U. S. Engineer Office, Huntington, West Virginia. Engineering and inspection was under the direction of Mr. Thurman R. Wathen, Engineer and Chief of the Rigid Pavement Branch of the Ohio River Division Laboratories, Mariemont, Ohio. Mr. James F. Brissendon, Partner, supervised construction for the W. L. Johnson Construction Company and Associates.

Table A

Estimated Quantities, Bid Prices and Actual Quantities for Final Payment

Description of Item	Est. Quantity	Actual Quantity	Unit Bid Price	Actual Cost
Grading	3,535 sq. yd.	3,535 sq. yd.	$ 0.55	$ 1,944.25
Filter Base	Job	Job	233.10	233.10
Plastic Membrane	125 sq. yd.	125 sq. yd.	312.50	306.25
8-Inch Paving	520 sq. yd.	520 sq. yd.	8.80	4,583.04
11-Inch Paving	1,025 sq. yd.	1,020 sq. yd.	9.95	10,156.96
12-Inch Paving	240 sq. yd.	243.1 sq. yd.	10.30	2,503.93
14-Inch Paving	545 sq. yd.	541.7 sq. yd.	10.90	5,904.53
16-Inch Paving	450 sq. yd.	451.4 sq. yd.	11.70	5,281.38
18-Inch Paving	210 sq. yd.	208.3 sq. yd.	12.35	2,572.51
20-Inch Paving	210 sq. yd.	208.3 sq. yd.	12.95	2,697.49
Cement, Type I & II	1,567 bbl.	1,578.5 bbl.	4.65	7,340.03
Steel Reinforcement	59,650 lb.	56,270 lb.	0.18	10,128.60
Substitution: Crushed for Natural Gravel	1,145 cu. yd.	1,148 cu. yd.	0.275	315.70
Resetting Forms	Job	Job	102.62	102.62
			TOTAL =	$54,070.39

PART II - DESIGN OF TEST SECTIONS

2.01 HISTORICAL BACKGROUND:

During 1953 and 1954, field survey crews from the Rigid Pavement Laboratory noted in their periodic condition surveys that a high degree of traffic channelization was occurring on several medium and heavy bombardment airfields. This channelization was believed to be directly related to the greater control of aircraft operations brought about by nose-gear steering and designated taxying paths (painted guide lines). Taxiways and the taxiway portion of aprons were noted to be primarily affected by this channelization. Observations at two specific airfields indicated that normal traffic with B-47 aircraft amounted to the equivalent of approximately 3000 coverages per year on certain prime taxiway features. Projecting this to a 20 year period, it can be seen that the pavements would receive in excess of 30,000 coverages which was considerably more than the 5000 coverages then assumed for the design life of the pavement.

To compensate for this channelization effect, the Rigid Pavement Laboratory presented a preliminary design for Taxiways and taxiway portion of aprons based on the 30,000 coverage criteria, which was submitted to the Chief of Engineers in February 1955. Subsequently the Rigid Pavement Laboratory was directed to prepare a design for a channelized traffic test

section to be presented at a meeting of the Board of Consultants in July 1955. As a result of this conference, modifications were made which resulted in a design acceptable to the Chief of Engineers, the Consultants, Representatives of the U. S. Air Force, and the Rigid Pavement Laboratory.

Two sites were selected for construction of two test sections, one consisting of nine individual test items on a low bearing value subgrade; and the other consisting of eight test items on a high bearing value subgrade. For the first condition, a 605 ft. strip just west of Sharonville No. 2 - Overlay Test Track was selected. The subgrade in this area was known to be a lean to fat clay (CL-CH) with a water table near the surface. For the second site, an area just north of Sharonville No. 1 - Overlay Test Track was chosen. This area indicated a silty sandy and gravel subgrade (GM_d) which could be processed to the desired strength. This track was 545 ft. long. Both tracks were designed for a 25 ft. width and each contained three plain concrete items; the remaining items contained reinforcing steel in various quantities. The geographical location of both test sites is shown by Figure 1.

2.02 DEFINITIONS:

In the following paragraphs and throughout the body of this report, various terms are used which for the purpose of clarity are defined as follows:

Test Track, Part 1 - The complete structure between stations 1 + 32.5S and 4 + 72.5 N, and encompassing Items 51-59 inclusive. The structure is 25-ft. wide, is built on a low-bearing value subgrade, and the centerline is offset 60-ft. west of the centerline of Overlay Test Track No. 2.

Test Track, Part 2 - The complete structure between stations 10 + 00 and 15 + 45, and encompassing Items 60-67 inclusive. The structure is 25-ft. wide, is built on a high-bearing value subgrade, and the centerline is offset 25-ft. east of the projected centerline of Overlay Test Track No. 2.

Pavement - The portland cement concrete pavement in either of the above Test Tracks.

Reinforcing - Round deformed steel bars of indicated diameter placed in both directions, securely tied at each intersection, and firmly located within the concrete pavement.

Transition Area - The 10-ft. long, 25-ft. wide, heavily reinforced pavement between each Item.

Dummy Joint - The transverse contraction joint in the plain pavement Items at 25-ft. spacing.

Doweled Construction Joint - The transverse construction joint at station 2 + 47.5 N. on Part 1 and 12 + 25 on Part 2 which divided each days pour when tracks were being constructed.

Item - An integral portion of the test track, upon which the full-scale tests will be performed.

Ramp Area - A section at each end of both test tracks on which backup and stop ramps are built to halt the traffic rig at the end of each pass.

Channelized Area - A 7.4-ft. wide strip in the center of each track, clearly lined and in which the load wheels will be confined when traffic is being applied.

Pass - One trip over the channelized area in either direction.

Coverage - Three trips over the channelized area in either direction.

Traffic Equipment - The vehicle used for trafficking the test tracks with the 100,000-pound load on 56 x 16-inch dual high pressure tires spaced 37-1/2 inches center to center, contact area 267 square inches.

2.03 DESIGN FEATURES:

a. Part 1: This channelized test track is 605 ft. in length, 25-ft. wide and is located west of Overlay Test Track No. 2 as shown on Figure 1. The "as constructed" details are shown on Figure 2. The overall design includes nine items, three of plain concrete and six of reinforced concrete. The following Table B gives pertinent design details of each Item as well as the transitions between Items.

Table B

Design Details of Items in Part 1

Item No.	Pavement Thickness (Inches)	Reinforcing Steel		Percent of Cross-Sect. Area
		Type	Location in Item	
51	11	#3-6" Centers	4" from Top Only	0.167
Trans.	11	#3-6" Centers	2" from Top, 4"from Top, 2" from Bottom.	0.501
52	11	#3-6" Centers	2" from Top, 2"from Bottom	0.335
Trans.	11	#3-6" Centers #5-8" Centers	2" from Top, 2"from Bottom 4" from Top	0.684
53	11	#5-8" Centers	4" from Top Only	0.349
Trans.	11	#5-8" Centers	4" from Top, 2" from Bottom	0.698
54	11	#5-8" Centers	4" from Top Only	0.349
Trans.	11 to 14	#5-8" Centers #5-12"Centers	4" from Top, 2"from Bottom 5" from Top	1.125
55	14	#5-12" Centers	4" from Top Only	0.183
Trans.	14	#5-12" Centers #5-6" Centers	4" from Top 5" from Top, 2"from Bottom	0.948
56	14	#5-6" Centers	4" from Top Only	0.366
Trans.	14 to 20	#5-6" Centers	4" from Top, 2"from Bottom	0.433
57	20	None	----	----
Trans.	20 to 18	#3-6" Centers	2" from Top, 2"from Bottom	0.194
58	18	None	----	----
Trans.	18 to 16	#3-6" Centers	2" from Top, 2"from Bottom	0.217
59	16	None	----	----

This test track slopes 0.32 percent to the south and 1 percent to the west throughout its length and width.

b. Part 2: This channelized test track is 545 ft. in length, 25-ft. wide and is located north of Overlay Test Track No. 1 as shown on Figure 1. The "as constructed" details are shown on Figure 2. The overall design includes eight items for test, three of plain concrete and five of reinforced concrete. The following Table C gives pertinent design details of each Item as well as the transitions between Items.

Table C

Design Details of Items in Part 2

Item No.	Pavement Thickness (Inches)	Reinforcing Steel		Percent of Cross-Sect. Area
		Type	Location in Item	
60	12	None	----	----
Trans.	12 to 14	#3-6" Centers	2" from Top, 2"from Bottom	0.283
61	14	None	----	----
Trans.	14 to 16	#3-6" Centers	2" from Top, 2"from Bottom	0.246
62	16	None	----	----
Trans.	16 to 11	#5-8" Centers #3-6" Centers	4" from Top 2" from Bottom	0.421
63	11	#5-8" Centers	4" from Top Only	0.349
Trans.	11	#3-6" Centers #5-8" Centers	4" from Top, 2"from Bottom 5" from Top	0.682
64	11	#3-6" Centers	4" from Top Only	0.167
Trans.	11 to 8	#3-6" Centers #5-11"Centers	4" from Top, 2"from Bottom 4" from Bottom	0.710
65	8	#5-11" Centers	4" from Top	0.352
Trans.	8	#3-8" Centers #5-11"Centers	2" from Top, 2"from Bottom 4" from Top	0.733
66	8	#3-8" Centers	2" from Top, 2"from Bottom	0.345
Trans.	8	#3-8" Centers	2" from Top, 4"from Top, 2" from Bottom	0.524
67	8	#3-8" Centers	4" from Top Only	0.173

This test track slopes 0.36 percent to the south and 1 percent to the west throughout its length and width.

c. General: As can be noted in Figure 2, all reinforced Items are 50 ft. in length with 10-ft. transitions between, and all plain concrete Items are 65 ft. in length with 10-ft. transitions between. There is no jointing in the reinforced Items; 25-ft. transverse dummy contraction joints are present in all plain concrete Items. At each end of both tracks a ramp area is provided for construction of backup and forward ramps to assist in halting the load rig at the end of a pass.

2.04 DRAINAGE SYSTEM:

a. Part 1: Drainage at this location consisted of surface drainage only and was accomplished by an open ditch approximately five feet west of the west edge of the track. The track was designed to have a surface and subgrade slope of 1 percent to the west and 0.32 percent to the south. General features of the area provided a natural slope of the terrain of 0.5 percent to the south, which was adequate to carry drainage in the open ditch. During construction, the flow line of the ditch was maintained approximately 6-inches below the top of subgrade. General high ground water prevailed during the construction period; however, by close control of the drainage ditch ponding of water

was kept to a minimum. Of minor importance is a previously built french drain constructed along the west edge of Overlay Test Track No. 2. This drain was uncovered during excavating operations and found to be only partially operative. Its location, approximately 2 feet to the east of the east edge of the track, is not considered to influence drainage of the test area to any great extent.

b. Part 2: Drainage at this location also consisted of surface drainage only and was accomplished similarly as for Part 1, with an open ditch on the west side of the track. The character of the subgrade in this area was such that natural vertical drainage was accomplished and the open ditch provided drainage only during excessive rainfall or snow. This track slopes 0.36 percent to the south and 1 percent to the west. The open ditch, maintained during construction, was approximately 5-feet west of the west edge of the track, its flow line was approximately 6-inches below subgrade elevation and it also sloped approximately 0.5 percent to the south for its entire length.

2.05 FIELD TESTING OF SUBGRADE:

a. General: Prior to construction of each track, auger holes were put down along the centerline of each track at 25-foot intervals and to a depth of approximately 6-feet below proposed subgrade elevation or to the sand and gravel layers known to exist in this area. In addition,

previous exploration data were available from the three other tracks in this area and served as a guide in developing the profile shown in this report.

b. Part 1: As shown by the profile of Figure 4 the subgrade for this track is composed of a fat clay (CH) material and a sandy clay (CL) material, underlain by a deep silty sandy gravel (GM_d). Ground water is generally high in this area, usually within 12 inches of the top of subgrade. Field bearing tests were made near the center of each test item and at least two unit weight tests were made near the location of each field bearing test. These tests were made generally when the subgrade had been trimmed to within 2 inches of final grade.

c. Part 2: As shown by the profile of Figure 5, the subgrade for this track is composed of a deep strata of a silty sandy gravel (GM_d). Auger borings indicated a relatively uniform material; however, proof rolling indicated clay pockets under Items 62 and 63 which were removed and replaced with approximately 30 inches of crushed gravel topped with approximately 6 inches of a stockpiled stabilized base material from Overlay Test Track No. 2. Some shallow clay pockets were also removed and replaced in Items 60, 61 and 67. Ground water at this location is also high; during construction it was observed to be approximately 3-feet below top of subgrade. Field bearing tests were made near the center of each test item, and at least two unit weight tests were made

near the location of each field bearing test. These tests were made following final grading of subgrade and at subgrade elevation.

PART III - RESULTS OF PRELIMINARY TESTS

3.01 GENERAL:

Inasmuch as preliminary testing consisted only of classification tests of auger hole samples, field bearing tests, and unit weight tests, the test results are grouped in the following sub-paragraphs rather than in an appendix. For additional data,reference is made to the Construction Reports for Sharonville No. 1 and No. 2 wherein extensive testing was reported for soils conditions in the immediate vicinity.

3.02 AUGER HOLE SAMPLES, PART 1:

Results of tests of auger hole samples are given by the representative curves of Figure 6, and by the profile developed on Figure 4. With the exception of Items 51 and 58 which are underlain by approximately two feet of fat clay (CH), the track generally is underlain either by a sandy clay (CL) or lean clay (CL) material. Underlying the fat clay material is a thin strata of sandy clay underlain by a deep strata of clayey sandy gravel (GC) material as shown by the profile of Figure 4. Atterberg limit tests indicated the following properties for the types of soils encountered:

Fat Clay (CH)		Sandy Clay (CL)	
Liquid Limit	= 61.7%	Liquid Limit	= 26.8%
Plastic Limit	= 26.5%	Plastic Limit	= 17.7%
Plasticity Index	= 35.2%	Plasticity Index	= 9.1%

Lean Clay (CL)		Silty Sandy Gravel (GM_d)	
Liquid Limit	= 49.6%	Liquid Limit	= 23.3%
Plastic Limit	= 23.6%	Plastic Limit	= 20.0%
Plasticity Index	= 26.0%	Plasticity Index	= 3.3%

Ground water at the time of the auger borings indicated a stable condition at about 2.0-ft. below the top of proposed subgrade.

The subgrade immediately beneath Items 52, 53, 54, 55 and 56 is identified as a lean clay (CL) while the subgrade beneath Item 59 is a sandy clay (CL).

Water contents indicated the lean clay (CL) material under items 52-57 to be 1 to 2 percent wetter than the plastic limit. The fat clay (CH) material was substantially at its plastic limit; and the sandy clay (CL) material about 4 percent wetter than its plastic limit.

Previous testing of identical material for other Sharonville projects indicate the CL and CH material to have density properties as follows:

Modified AASHO Maximum Dry Weight = 115.2 lb/ft^3

Optimum Water Content = 14.1 percent

3.03 FIELD BEARING AND UNIT WEIGHT TESTS, PART 1:

Immediately prior to final grading, field bearing and unit weight tests were made in each item at subgrade elevation. The following Table D

presents the results of these tests. No correction of "k" values was made for saturation since the material tested was either at or above its plastic limit.

Table D

Results of Field Bearing and Unit Weight Tests, Part 1

Item No.	Location	Subgrade Modulus "k" (lbs/in^3)	Water Content in Percent (4 Tests)	Unit Dry Weight (lbs/ft^3) (4 Tests)	Percent of Modified AASHO Density
51	Sta. 0 + 92 S, on Centerline	44	28.4	92.6	80.3
52	Sta. 0 + 32 S, on Centerline	52	30.0	90.8	78.8
53	Sta. 0 + 15 N, on Centerline	46	28.4	93.6	81.2
54	Sta. 0 + 83 N, 4' West of Centerline	51	27.3	94.5	82.0
55	Sta. 1 + 45 N, on Centerline	50	----	----	----
56	Sta. 2 + 04 N, on Centerline	47	25.4	99.4	86.2
57	Sta. 2 + 75 N, on Centerline	27	22.6	103.0	89.3
58	Sta. 3 + 53 N, on Centerline	30	31.2	89.7	77.8
59	Sta. 4 + 30 N, on Centerline	47	22.5	102.5	88.8

A block diagram, see Figure 7, is included to indicate "k" relationships between individual items.

3.04 AUGER HOLE SAMPLES, PART 2:

Results of tests of auger hole samples are given by the representative curve of Figure 8. This silty sandy gravel (GM_d)is predominate in the subgrade of Part 2, as indicated by the profile, see Figure 5. Some clay pockets were uncovered in proof rolling prior to concreting operations and were removed and back-filled with 1-1/2-inch crushed gravel topped with 6-inches of stabilized base material. The depths of these pockets varied from 30 inches under item 62 to about 12 inches in item 60. Clay pockets were removed with a 3/4-yard clam shell bucket, and the crushed gravel was rolled in place by the tracks of a D-7 bull-dozer. Generally the gravel was bladed into 12-inch layers and tracked in by several passes of the D-7 bull-dozer. A gradation curve for the 1-1/2-inch gravel used to replace the clay pockets is shown on Figure 9. Compacted by Modified AASHO procedure at a water content of 5.8 percent, this material produced a dry density of 146.4 lbs/ft^3 (See Figure 10). A similar curve for the original material is shown on Figure 11. Compacted at a moisture content of 7.0 percent this material yielded a dry density of 137.8 lbs/ft^3.

Ground water was indicated by the auger borings to be approximately 3-feet below the top of the finished subgrade.

3.05 <u>FIELD BEARING AND UNIT WEIGHT TESTS, PART 2</u>:

Immediately prior to final grading and following proof rolling, field bearing tests and unit weight tests were run near the center of each item. Field bearing tests were run in accordance with the procedure outlined in paragraph 3-03, Part XII of the Engineering Manual for Military Construction. A correction was made for bending of the plate since all values obtained were in excess of 200 $lbs/in^2/in$. Results of field bearing tests and unit weight tests adjacent to the field bearing tests are given in Figures 12 - 20 inclusive. A block diagram, see Figure 21, is included to indicate "k" relationships between individual items. The following Table E presents a summary of field bearing tests, unit weight tests and percent of Modified AASHO densities obtained.

Table E

Results of Field Bearing and Unit Weight Tests, Part 2

Item No.	Location	Subgrade Modulus "k" (lbs/in^3)	Water Content in Percent (4 Tests)	Unit Dry Weight (lbs/ft^3) (4 Tests)	Percent of Modified AASHO Density
60	Sta. 10 + 40, on Centerline	335	6.3	140.7	95.8
61	Sta. 11 + 09, 3.5' W. of Centerline	300	6.9	137.1	99.4
62	Sta. 11 + 91, 1.5' E. of Centerline	360	6.4	126.3	86.2
63	Sta. 12 + 56, 1.0' W. of Centerline	385	6.7	127.0	86.7
64	Sta. 13 + 28, on Centerline	320	5.8	136.1	98.8
65	Sta. 13 + 94, 1.0' E. of Centerline	300	6.9	136.8	99.3
66	Sta. 14 + 43, 2.0' E. of Centerline	345	6.1	131.1	95.2
67	Sta. 15 + 11, 3.0' E. of Centerline	300	6.7	141.0	96.2
Trans.	Sta. 10 + 93, 5.0' E. of Centerline	340	7.0	136.4	93.2

PART IV - CONSTRUCTION

4.01 GENERAL:

The Contractor, W. L. Johnson Construction Company and Associates, Columbus, Ohio, began construction activities on 22 November 1955 and completed all work required by the Contract, with exception of sealing joints, on 10 January 1956. Joints were sealed on 7 February 1956 when favorable weather conditions were obtained. Contractural work included fine grading, fabrication and placing of reinforcing steel, construction of the concrete pavements, and protecting and curing of the finished concrete.

4.02 PRELIMINARY SITE PREPARATION:

a. Part 1: Preliminary grading in this area was done by government forces and consisted of rough grading, roto-tilling and rolling to within 2 inches of finished grade. Rough grading was begun 8 September 1955, using a D-7 Caterpillar tractor with bull-dozer attachment. Excess material was hauled from the site by a Le Tourneau 11-yard scraper unit. Excavation was accomplished at intermittent periods due to frequent rainfall. When approximately 6 inches from finished grade, a farm-type Roto-Tiller pulled by a Caterpillar D-7 tractor was used to pulverize and mix the top 6 - 8 inches of subgrade. Following this operation the area was rolled at least twice with an empty pneumatic-tired four-wheel roller with tires

inflated to 45 psi and towed by a Caterpillar D-7 tractor. Empty, this roller has a weight of 15,000 pounds. Following this operation, a 3-ton smooth wheel tandem roller made two passes over the area to seal the surface from infiltration of rainfall. Eighteen inches of straw was then placed over the area for protection against freezing weather and against evaporation of water from the soil. Excavation and preliminary preparation was in an area generally 10-feet wider than the 25-foot width of the track, 2-1/2 feet on the east side of the track and 7-1/2 feet on the west side of the track.

b. Part 2: Preliminary grading in this area was also done by government forces and consisted of grading and rolling to within 2 inches of final grade. Rough grading was begun on 17 November 1955, using a Caterpillar D-7 tractor with bull-dozer attachment. When approximately 6 inches from finished grade, a pneumatic-tired four-wheel roller was brought in and the entire area rolled at least twice with tires inflated to 55 psi and the load box loaded to 25,000 pounds. No protection was afforded this area since it was considered free draining and not particularly susceptible to frost action. Preliminary grading was completed on 26 November 1955.

4.03 EXCAVATION AND FINISHING SUBGRADE:

a. Part 1: The contractor moved into this area on 7 December 1955 and with a Caterpillar Diesel Motor Patrol Grader cut the existing subgrade to approximately 2 inches above grade. Extremely unfavorable weather, consisting of rain, snow and freezing temperatures necessitated covering the area again with straw after first placing a layer of Kraft waterproof paper over the cut area. On 29 December 1955, the area was uncovered and the contractor began final grading, beginning at the south end of the track. Grade was generally cut to 1-inch above final grade with the patrol grader and the final 1 inch of soil removed with a subgrade planer in 1/8-inch to 1/4-inch increments. This planer rode the forms which had previously been placed and checked for elevation and alignment and was pulled by a small utility truck which was equipped with a hoist to lift and travel with the planer. Some rutting occurred in the subgrade which was filled in by hand and satisfactorily tamped into place at the required moisture content. Following the final pass by the planer, a small 3-ton tandem roller made 2 passes over the finished area to seal the surface and iron out small irregularities. A string line was used to check the final grade between the forms, which was done by measuring from the string line to subgrade every 3 feet on 10-foot ranges. In all cases the subgrade was either at grade or not over 1/4-inch below grade.

After acceptance by the inspector, the contractor was permitted to cover the subgrade with one layer of new Kraft waterproof paper conforming to Federal Specification UU-P-264, Type II, which was securely nailed into the subgrade by 14 penny spikes. The subgrade paper was generally in rolls 4-feet wide and 100-feet long. A 3-inch lap was made at the edges and spikes were generally put in at 24-inch intervals.

A general unworkable soil condition was found in parts of items 57 and 59 due to an excess of moisture. This material was removed to a depth of about 15 inches with a D-7 bull-dozer and replaced with a similar drier soil, which was obtained from a hole dug nearby. Approximately 50 cubic yards of soil was replaced in these items. Compaction to a comparable density with the surrounding area was accomplished by rolling with a loaded scraper unit.

The entire area was covered with large mats following completion of fine grading. These mats were placed over the forms, allowing a free air space for the full depth of the forms.

b. Part 2: This area was chosen by the contractor for his first item of work since preliminary site preparation at this location was most nearly completed at the time of his arrival. Final grading was begun on 22 November 1956 and was completed on 23 December 1956. Considerable time was lost in this interim because of rain, snow and freezing weather.

As in Part 1, grading to within 1 inch of final grade was accomplished with a patrol grader, after which a subgrade planer riding the forms cut the remaining grade down in 1/4-inch increments. Following the final pass of the grader; concrete sand was spread on the surface of the subgrade to fill in the void spaces around large gravel and a small 3-ton tandem smooth-wheel roller made two passes over the finished area. Subgrade elevations were checked with a string line between the forms on 10-foot intervals, every 3 feet. In all cases the subgrade was either at grade or not over 1/4-inch below grade.

During grading operations it was noted that some weaving was occurring under traffic of the patrol grader in some locations. These sections were removed by bull-dozer and clam-shell and replaced with 1-1/2-inch crushed gravel topped with a high quality stabilized base course material recovered from Sharonville No. 2 - Test Track. Maximum depth of material removed was 30 inches in items 61, 62, and 63. Other removed areas averaged less than 12 inches. The material used to replace these sections was tracked in with a D-7 bull-dozer in 12-inch layers and the topped material was rolled with the patrol grader several times to insure good compaction and to observe that no further weaving occurred under traffic. Figure 22 shows the location of soft spots in the subgrade which were replaced. Following

proof-rolling and checking of final grade, the entire area was covered with Kraft waterproof paper 4-feet wide and 100-feet long. The paper was nailed into the subgrade with 14 penny spikes and generally a 3-inch lap was made at all interior edges of the paper.

4.04 PAVEMENT FORMS:

a. General: Due to the relatively small amounts of concrete to be placed and the several thicknesses of pavement used, more latitude was allowed in the size and method of form placement than normally allowed on paving projects. The Contractor had 17-inch specially built channel-type steel forms from an airport paving job at Lockbourne A.F.B., Ohio and 21 and 24-inch dual-purpose steel forms from an airport paving job at Wright Patterson A.F.B., Ohio. These forms were steel channel-type forms, in good condition, and in 10-foot lengths.

b. Part 1: For the 11-inch pavement of Items 51 through 54, conventional Heltzel 11-inch steel forms were used in 10-foot lengths securely pinned and locked together with "bull-pins" 24-inches long. These forms rested flush with the top of the subgrade. For the 14-inch pavement of Items 55, 56 and 59, the 17-inch channel-type steel forms were used, also in 10-foot lengths, securely pinned and locked together with 24-inch "bull-pins". In this instance, the Contractor was permitted to excavate 3 inches of subgrade directly under the forms for seating the forms. For the 18-inch pavement of Item 58, the 17-inch channel-type forms were used, in 10-foot lengths and similarly pinned and locked. The

Contractor was permitted in this instance to build up the subgrade 1-inch directly under the forms with a good quality sand and gravel which was hand-tamped in place. For the 20-inch pavements of item 57, the 21-inch channel-type forms were used, in 10-foot lengths and similarly pinned and locked. In this case, the Contractor was permitted to dig out 1-inch of the subgrade directly under the forms in order to utilize this depth of form. For the 18-inch pavement of item 58, the 17-inch channel-type forms were similarly used with the Contractor filling in 1-inch of compacted sand and gravel under the forms. For the 16-inch pavement of item 59, the 17-inch channel-type forms were used in 10-foot lengths and similarly pinned and locked. The Contractor was permitted to excavate 1-inch of subgrade directly under the forms in order to utilize this depth of form. Seventeen-inch forms were used for the transition between items 54 and 55, and 21-inch forms were used for the transitions between items 56 and 57, items 57 and 58 and items 58 and 59.

c. Part 2: For the 8-inch pavement of items 65, 66 and 67, conventional Heltzel 9-inch steel paving forms were used, in 10-foot sections, securely pinned and locked together with 24-inch "bull-pins". The Contractor was permitted to excavate 1 inch of the subgrade beneath the forms in order to use this depth of form. For the 11-inch pavement of items 63 and 64, conventional Heltzel 9-inch steel paving forms with

2-1/4-inch wood blocking on the base were used. These forms were also in 10-foot lengths, were similarly pinned and locked, and rested just below the top of the subgrade. For the 12-inch pavement of item 60, conventional Heltzel 9-inch steel paving forms, with 2-1/4-inch wood blocking on the base, in 10-foot lengths, securely pinned and locked, were used. The Contractor was permitted to fill in approximately 1 inch under the forms with a well-compacted sand and gravel in order to utilize this depth of form. For the 14-inch pavement of item 61, conventional Heltzel 9-inch steel paving forms with two strips of 2-1/4-inch wood blocking on the base, in 10-foot lengths, securely pinned and locked, were used. The Contractor was permitted to fill in approximately 1/2-inch under the forms with a well-compacted sand and gravel in order to utilize this depth of form. For the 16-inch pavement of item 62, the 17-inch channel-type form was used, in 10-foot lengths, securely pinned and locked. The Contractor in this instance was permitted to excavate 1 inch of material under the forms in order to utilize this depth of form. For the transitions; the 9-inch form with the double 2-1/4-inch blocking was used between items 60 and 61, the 17-inch channel-type form was used between items 61 and 62, 62 and 63, and the 9-inch form was used between items 64 and 65.

d. Additional Forms: In order that the finishing machine could be seated at the beginning of a lane, and ridden off at the end of a lane, extensions of 17.5 feet were built on the north end of each track and 7.5 feet on the south end of each track.

e. Checking of Forms: Forms were checked by government forces for both elevation and alignment at least three times prior to pouring concrete. In no case was a form allowed to be below grade, and not over 1/4-inch above grade. Forms were oiled immediately prior to concreting operations.

4.05 REINFORCING STEEL:

a. Source: All reinforcing steel used in the contract was purchased from the Pollack Steel Company, Marion, Ohio and was delivered to the test site by commercial trucks. A level area was cleared for the contractor on the concrete portion of Sharonville No. 2 Test Track where assemblies were made by contractors forces.

b. Testing: Steel furnished by the Pollack Steel Company was round deformed rail steel, hard grade bars which conformed to ASTM Specification A305-53T and to Federal Specification QQ-B-71A-Type B-Grade 5. A Mill Certificate was furnished for both the #3 and #5 bars. Lengths were generally 23 3/4 and 26 1/2 feet for the #3 bars and 24 3/4 and 27 1/2 feet for the #5 bars. This allowed for the 24-diameter lap required in the Contract Specification. The following Table F presents the results of tests on the steel as contained in the Mill Certificates:

Table F

Results of Tests of Reinforcing Steel
As Reported by Pollack Steel Co.

Deformed Bar Designation	Wt. in Lbs. per Ft.	Dia. in Inches	Elastic Limit PSI		Ultimate Strength PSI		Remarks
			Spec.	Test	Spec.	Test	
#3	0.376	0.375	50,000	64,000	80,000	103,000	2 Tests
#5	1.043	0.625	50,000	62,497	80,000	104,466	3 Tests

c. Assembly: All bars were assembled into mats on a level portion of Sharonville No. 2 Test Track prior to placing. All intersections were wired together by conventional hand methods using a tool specifically designed for this purpose. The finished mats were hauled by a small truck equipped with a motor operated crane and placed between the forms by hand methods. Steel chairs spaced at 24-inch intervals were used to support the mats. These chairs rested on the subgrade paper and were adjustable to the required height. All steel, with exception of the transition sections between the plain concrete items, was placed prior to concreting. Locations, spacing, overlap and size of steel was checked by government forces prior to concreting. The 9 3/4 by 10-foot mats used in the transitions between the plain concrete items were placed during concreting operations; the concrete being struck off at the correct elevation and the mats deposited by hand.

d. Concreting: During concreting operations no difficulty was experienced in depositing the concrete on the steel although some sagging was noted in the #3 sections.

4.06 SAND SECTION:

a. General: In order to study the action of a slab on a free-draining base a 4-inch filter was provided under Item 54. The filter material used was a concrete sand furnished by the Camp Dennison plant of the Ohio Gravel Company. A mechanical analysis of this material is shown on Figure 23. Compacted by Modified AASHO procedure at a water content of 5.9 per cent, this material yielded a maximum unit dry weight of 117.0 lbs/ft^3.

b. Placing: The subgrade was cut to grade by a patrol grader and subgrade planer during regular subgrade operations operating from south to north on the track. Filter sand was dumped by truck on the finished subgrade and raked in place. Attempts to roll the material with a 3-ton tandem smooth wheel roller were futile and a mechanical hand operated tamper was used. Some success was attained but generally compaction of this type of material was unsuccessful. The subgrade planer made a final pass over the item striking off excess material after which subgrade paper was nailed in place as in other items. No density tests were run on the finished grade; however, inasmuch as the contractor had made every effort to achieve compaction the item was accepted on the basis that it appeared to be compacted as good as was reasonably possible.

4.07 PLASTIC MEMBRANE:

a. General: In order to control pumping at joints, plastic membrane was specified under Item 59; no material other than subgrade paper is present under Items 57 and 58. Membrane furnished by the Contractor was obtained from the Scioto Supply Company, Columbus, Ohio and was a flexible polyvinyl chloride. This material came in two sheets 24 1/2" wide and 45' long. Thickness of each sheet varied from .0185 to .0190 millimeters. All seams were closely examined and found to be as strong as the unseamed material.

b. Placement: This material was placed one day before concreting operations in Item 59. The sheets were laid directly on the subgrade paper and one sheet was placed directly on top of the other. Location of the membrane was within the forms between Stations 4 + 12.5N and 14 + 57.5N. The membrane was securely anchored in place by 14 penny spikes around the edges only.

4.08 PAVEMENT JOINTS:

a. General: As can be seen from Figure 2, only two types of pavement joints were used in construction of the two test tracks. At the close of each days pour, the contractor was required to put in a doweled butt type construction joint as shown on Detail "B" of Figure 2. The other type of joint was the dummy groove joint which in this construction was used in the plain concrete items only. There are no longitudinal joints in either track.

b. Doweled Construction Joint: These joints are present at Station 2+47.5N (Item 57) in Part 1, and at Station 12 + 25 (Item 62) in Part 2. Dowels used were extra strong pipe, 1 1/2" in diameter, 20" long and were filled with concrete. Dowels were wired in place at the mid-plane of the slab through wooden forms which were in turn securely braced by heavy stakes driven into the subgrade.

c. Dummy Groove Joint: These joints are present in the plain concrete items of both tracks, are transverse and are spaced every 25 feet beginning at the doweled construction joints and extending to the end of both tracks. These joints were formed by pressing 3/8" masonite strips into the soft concrete directly behind the finishing machine. Original survey stakes were used to locate the joints. These strips were pressed down to 1/6 of the slab thickness and a grooving tool was used to round off the edges thus formed.

4.09 CONCRETE:

a. General: The concrete for both tracks was composed of fine and coarse aggregate, cement and water, and was designed to have a 90-day flexural strength of not less than 700 psi. The fine aggregate was a natural sand, and the coarse aggregate was crushed gravel, each furnished by the Camp Dennison Plant of the Ohio Gravel Company. Original specifications called for natural gravel coarse aggregate but a change order

was issued designating the crushed gravel. The maximum size of coarse aggregate was 1-1/2 inches. The cement used was Miami Portland furnished by the Southwestern Portland Cement Company, Fairborn, Ohio. Mill certificates of compliance were furnished by the Company certifying that the cement conformed to current Federal Specifications for Type 1 cement. The air entraining admixture, Vinsol resin, was interground with the cement. All concrete was batched at the Evendale Plant of the Richter Concrete Corporation, Cincinnati and was hauled to the site in Ready Mix trucks having a capacity of 5 cubic yards. The length of the haul was approximately 3 miles. Unloading of the trucks and placing was accomplished both by chute method and by 3/4 cubic yard buckets using a truck mounted crane. Physical conditions at the site necessitated generally placing all concrete from the east side of the tracks. The 1 to 2-inch slump requirement made handling of the concrete extremely difficult on Part 2, which was poured first; consequently the Contractor, at his own expense, chose to add an additional 1/2 sack of cement per cubic yard to the concrete in Part 1 to ease this difficulty. An additional 1-inch slump was authorized by inspection forces for this track.

b. Design of Mix: Mix designs were prepared by the Concrete Section of the Ohio River Division Laboratories, Mariemont, Ohio and utilized the knowledge and experience of considerable use of the type of materials furnished. Mix designs were as follows:

Part 2

Cement: 5.5 Bags per Cu. Yd.

Water-Cement Ratio: 0.44 by Weight

Slump: 1 - 2 Inches

Air Entrainment: 4 - 5 Percent

Mix Proportions by Weight:

1: 2.08: 1.24 (3/4"): 2.92 (1-1/2")

Weights for 1 Cubic Yard of Concrete:

(Saturated, Surface Dry Aggregates)

Cement	517 lbs.
Sand	1076 lbs.
3/4" Crushed Gravel	646 lbs.
1-1/2" Crushed Gravel	1510 lbs.
Mixing Water	228 lbs.

Part 1

Cement: 6.0 Bags per Cu. Yd.

Water Cement Ratio: 0.406 by Weight

Slump: 2-3 Inches

Air Entrainment: 4 - 5 Percent

Mix Proportions by Weight:

1: 1.91: 1.15 (3/4"): 2.69 (1-1/2")

Weight for 1 Cubic Yard of Concrete:

(Saturated, Surface Dry Aggregate)

Cement	557 lbs.
Sand	1064 lbs.
3/4" Crushed Gravel	640 lbs.
1-1/2" Crushed Gravel	1496 lbs.
Mixing Water	226 lbs.

c. Concrete Control: Control of the concrete was exercised as follows:

Batching Plant: An inspector was stationed at this location during all of the concrete placement. Frequent determination of the moisture content of the aggregate and an occasional check on the gradations were made. Prior to a days pour, the air content was checked at the plant before the first truck was released and adjustments were made at that time. A close check on the slump was made and some batches were rejected when the slump was exceeded.

At the Construction Site: At least three inspectors were at the site at all times during a pour and fairly close control was obtained. Periodic checks of air content were made using a Tarrant Air Meter. Visual checks were made of each trucks contents and batches were rejected when obviously too wet. Occasionally the contractor was permitted

to add water to the truck contents when the concrete could not be deposited from the truck. Four 6 x 6 x 36-inch beams were made from representative concrete in each Item of both tracks. Two of the beams were taken to the laboratory for curing under controlled conditions; the remaining two were deposited on a selected area to be field cured.

d. Placing Concrete:

Part 2: This track was poured on two separate days, beginning at the north end of the track and working south. The first pour was made on 27 December 1955 and was stopped at Station 12 + 25 in Item 62, where a doweled transverse construction joint was installed. The track was completed on 28 December 1955, extending from the doweled construction joint to the south end of the track. Four hundred and seventy-five cubic yards of concrete were placed; theoretical quantities totaled 478.3 cubic yards, which represented a deficiency of .68 percent. On the first day, pouring began at 10:30 AM and was completed at 8:30 PM with 245 cubic yards being placed.

Adverse weather with temperatures ranging from 18° F at 7:00 AM to 33° F in the afternoon made concrete placing a problem. The subgrade had previously been protected against freezing by a covering of tarpaulins and by using two gasoline blowers with 30,000 BTU capacity circulating air from the north end of the track under the tarpaulins. On

the first days pour, concrete was placed by means of two truck-mounted cranes on either side of the track equipped with 3/4-cu. yd. buckets. A Jaeger-Lakewood finishing machine equipped with double 25-foot screeds made two passes over the poured sections. No vibration was required for the entire days pour which was 8 and 11-inch reinforced pavement; the 11-inch sections were however vibrated by hand methods just ahead of the first screed pass. Very little difficulty was experienced in the actual placing although some minor trouble developed in getting the concrete out of the buckets used. The screeding operation was followed by hand floating from either side of the track, straight edging and burlap dragging in that order. Since there were no transverse joints in the reinforced pavement Items, the only edging done was along the forms.

On the second days pour, operations were changed slightly with the contractor being permitted to operate concrete trucks on the finished subgrade, along with the truck-mounted crane and bucket. Generally, the east half of the track was poured with the crane and bucket and the west half of the track with trucks on the subgrade. Some minor rutting developed but by careful routing of the trucks, rutting was kept to a minimum. Finishing was accomplished as above except in this section of track dummy contraction joints were required every 25 feet. These joints were constructed by pressing masonite strips into the soft concrete following the final floating.

Edging the joint was accomplished from a bridge across the track after which the masonite strips were removed. These joints were located from the original survey stakes which had been left in place.

Part 1: This track was also poured on two separate days, beginning at the north end of the track and working south. The first pour was made on 9 January 1956 and was stopped at Station 2 ⁄ 47.5 N in Item 57, where a doweled transverse construction joint was installed. The track was completed on 10 January 1956, extending from the doweled construction joint to the south end of the track.

Six hundred and sixty-nine cubic yards of concrete were placed in the track; theoretical quantities totaled 667.9 cubic yards which indicated an everage of .16 percent. On the first day, pouring began at 12:20 PM and was completed at 11:30 PM with 315 cubic yards of concrete placed. On the second day, pouring began at 9:30 AM and was completed at 7:15 PM with 354 cubic yards of concrete placed.

Adverse weather again hampered concreting operations especially on the second day when a light snow, sleet and almost a constant drizzle of rain fell. Temperatures ranged from 11° F at 8:00 AM to 33° F in the mid-afternoon. A pliofilm sheeting was placed over the finished concrete on the second days pour to keep the rain, sleet and snow off the fresh concrete until it could be covered with cotton mats. Again it was necessary to protect

the subgrade from freezing which was done by forcing hot air under tarpaulins which were bridged between the forms. Pouring was further slowed down by inability to use more than one truck-mounted crane since it was impossible to work from the west side of the track. Concrete trucks were emptied directly by chute from old pavement adjacent to the east side of the track. The same finishing equipment was used as in Part 2 and similar procedures were followed in placing, screeding, floating, edging, burlap dragging and forming the joints. One exception was in the Items over 11-inches thick which required vibration. This was accomplished by two, mechanical hand-operated vibrators just ahead of the first screed on the finishing machine.

e. Curing Concrete: No curing compound was used on these tracks due to prevailing weather conditions. As soon as possible after placement, the poured area was first covered with Sisalcraft paper, then cotton mats, 18 inches of straw and tarpaulins. During the 7-day curing period, it was observed through thermocouple readings that none of the concrete in either track was close to freezing temperature. Thermocouples were installed in a 11-inch reinforced section and a 14-inch plain section of Part 2. Figure 24 presents the readings taken together with the air temperatures for the first 11 days of curing.

f. Sealing Joints: Sealing of joints was purposely delayed until

favorable weather with no penalty to the Contractor. Favorable conditions did not occur until early February 1956 or about one month after placement. The Contractor was prepared in advance and sealed all the joints on 7 February 1956. A jet-fuel-resistant joint seal was used identified as Aero-Sealz. This material was excess material from a recently completed job at Lockbourne Air Force Base, Ohio and had been previously tested and accepted on that project. Joint seal material was heated in a double wall Agitator-type kettle under controlled temperature and was applied with a special pressure-type joint sealing applicator. Joints had previously been blown out with compressed air and were entirely free from foreign particles and water. Inasmuch as concrete placement had taken place in cold weather, only about one-half of the dummy contraction joints had opened and these by only small amounts.

g. Concrete Strength and Physical Properties: Four beams were made from representative pours of each Item of both tracks; two beams from each Item were field-cured at the site and the remaining two were taken to the laboratory and cured under controlled conditions. When Items fail on each test track, the field-cured beams will be sent to the laboratory and tested at once. Tests to which the concrete and/or beams were subjected were as follows:

Slump - In accordance with ASTM C143-52

Air Content - In accordance with ASTM C231-54

Dynamic Modulus of Elasticity - In accordance with ASTM C215-47T

Flexural Strength - In accordance with ASTM C78-49

Density - In accordance with CRD C23-48

The following Tables "G" and "H" presents a summary of the results obtained from all beams tested for both tracks.

Table G

RESULTS OF CONCRETE TESTS - PART 1

Item No.	C.F. Bags/Yd.^{3}	Slump (Inches)	Air %	Density Lbs/Ft.^{3}	Dynamic "E" PSI x 10^{-6} 28-Day Lab. Cured	Dynamic "E" PSI x 10^{-6} 90-Day Lab. Cured	Dynamic "E" PSI x 10^{-6} 90-Day Field Cured	Static "E" PSI x 10^{-6} 28-Day Lab. Cured	Static "E" PSI x 10^{-6} 90-Day Lab. Cured	Static "E" PSI x 10^{-6} 90-Day Field Cured	Flexural Strength PSI 7-Day Lab. Cured	Flexural Strength PSI 28-Day Field Cured	Flexural Strength PSI 90-Day Lab. Cured	Flexural Strength PSI 90-Day Field Cured
51	6.0	3	5.2	148.2	4.90	6.03	5.97	4.43	3.84	3.70	----	660	775	675
52	6.0	3-1/2	3.6	144.8	4.82	5.99	5.89	4.11	3.56	3.43	----	585	700	605
53	6.0	4	6.3	145.2	4.80	5.35	4.83	4.26	3.56	3.43	420	605	665	590
54	6.0	3	4.8	147.9	5.13	5.55	5.34	4.11	3.43	3.43	475	680	655	655
55	6.0	3-1/4	4.9	146.3	5.10	5.77	5.01	4.80	4.58	3.84	600	665	780	705
56	6.0	2-1/4	4.1	148.3	5.38	5.76	6.00	5.05	4.37	4.80	645	570	800	725
57	6.0	1	2.0	153.3	5.42	6.55	6.00	5.48	4.80	4.01	705	725	795	695
58	6.0	4	3.9	152.8	5.65	6.26	5.69	4.60	4.18	3.56	660	655	775	685
AVE.	6.0	3	4.4	148.3	5.15	5.91	5.59	4.61	4.08	3.78	585	643	743	667
59	5.5	2-1/4	2.8	152.8	6.25	6.37	5.75	4.25	5.06	3.10	660	855	815	650

Table H

RESULTS OF CONCRETE TESTS - PART 2

Item No.	C. F. Bags/Yd.3	Slump (Inches)	Air %	Density Lbs/Ft.3	Dynamic "E" PSI x 10^{-6} 28-Day Lab. Cured	Dynamic "E" PSI x 10^{-6} 90-Day Lab. Cured	Dynamic "E" PSI x 10^{-6} 90-Day Field Cured	Static "E" PSI x 10^{-6} 28-Day Lab. Cured	Static "E" PSI x 10^{-6} 90-Day Lab. Cured	Static "E" PSI x 10^{-6} 90-Day Field Cured	Flexural Strength PSI 14-Day Lab. Cured	Flexural Strength PSI 28-Day Lab. Cured	Flexural Strength PSI 90-Day Lab. Cured	Flexural Strength PSI 90-Day Field Cured	Flexural Strength PSI 150-Day Field Cured
60	5-1/2	2	3.7	150.4	5.95	6.15	5.17	3.90	4.78	3.59	----	615	765	610	810
61	5-1/2	3	4.7	149.6	5.36	5.75	5.35	3.21	4.11	3.85	----	550	650	620	730
62	5-1/2	3-1/4	4.2	149.2	5.54	5.85	5.06	3.43	5.05	3.83	----	[illegible]85	700	620	695
63	5-1/2	3	3.9	150.4	5.55	5.63	5.58	4.36	4.00	3.71	680	830	795	700	855
64	5-1/2	3	5.6	147.3	5.55	6.00	5.13	4.35	4.56	3.56	635	685	680	710	790
65	5-1/2	5-1/2	7.4	146.1	4.96	5.58	4.83	3.84	3.59	2.95	655	525	700	540	675
66	5-1/2	2-3/4	4.6	151.0	5.71	5.99	5.52	4.42	4.26	3.59	740	740	720	695	790
67	5-1/2	4	4.4	149.5	5.38	5.80	5.36	4.42	4.42	4.10	665	730	725	710	735
AVE.	5-1/2	3-1/4	4.8	149.2	5.50	5.84	5.25	4.00	4.34	3.65	675	660	715	650	760

4.10 WEATHER AND CONTINGENCIES:

Weather conditions were generally very unfavorable during the construction period, which extended from 17 November 1955 through 7 February 1956. Protecting the subgrade from freezing temperatures was the major source of difficulty and considerable quantities of Siselcraft paper and straw were used in this operation. As previously stated, gasoline blowers were used prior to concreting operations on both tracks to protect the subgrade. The following Table I presents a record of the weather conditions for the entire construction period.

Table I

Weather Data During Construction

Date 1955	Temperature, Degrees F. Max.	Min.	Avg.	Precipitation (Inches)	Construction Operation
Nov.					
18	34	18	26.0	0.28	Grading, Part 2
19	34	27	30.5	0.21	" "
20	39	29	34.0	----	" "
21	54	34	44.0	----	" "
22	64	31	42.5	----	" "
23	62	35	48.5	0.65	" "
24	39	26	32.5	----	Holiday
25	43	26	34.5	----	Grading, Part 2
26	43	22	32.5	----	" "
27	48	27	37.5	0.03	" "
28	16	10	13.0	T	" "
29	24	15	19.5	T	" "
30	29	22	30.5	T	" "
Avg.	40.7	24.8	32.7	Total 1.17	
Dec.					
1	33	15	24.0	0.11	Grading, Part 2
2	46	32	39.0	0.37	" "
3	60	46	53.0	0.02	" "
4	60	35	47.5	----	" "

Table I (Cont'd)

Weather Data During Construction

Date 1955	Temperature, Degrees F. Max.	Min.	Avg.	Precipitation (Inches)	Construction Operation
5	37	22	29.5	----	Setting Forms, Grading Part 2
6	35	15	25.0	----	" " "
7	41	23	32.0	----	" " "
8	41	22	31.5	----	" " "
9	31	23	27.0	T	" " "
10	23	14	18.5	----	" " "
11	32	18	25.0	----	" " "
12	34	16	25.0	----	" " "
13	36	16	26.0	----	" " "
14	44	28	36.0	0.05	" " "
15	29	8	18.5	0.01	" " "
16	21	6	13.5	----	" " "
17	39	20	29.5	----	" " "
18	46	25	35.5	----	" " "
19	29	20	24.5	----	" " "
20	28	15	21.5	T	" " "
21	33	18	25.5	----	" " "
22	40	18	29.0	----	" " "
23	47	36	41.5	T	" " "
24	59	45	52.0	T	" " "
25	60	27	43.5	T	" " "
26	38	27	32.5	T	" " "
27	34	23	28.5	----	Concreting, Part 2
28	43	22	32.5	----	Concreting, Part 2
29	49	36	42.5	T	Grading, Part 1
30	36	22	29.0	----	" "
31	58	24	31.0	----	Grading, Setting Forms, Part 1
Avg.	39.4	[illegible]3.1	31.3	Total 0.56	
1956 Jan.					
1	20	47	33.5	----	Holiday
2	49	34	41.5	T	Holiday
3	47	33	40.0	----	Grading, Setting Forms, Part 1
4	40	22	31.0	----	" " "
5	49	20	34.5	----	" " "
6	58	33	45.5	----	" " "

Table I (Cont'd)

Weather Data During Construction

Date 1956	Temperature, Degrees F. Max.	Min.	Avg.	Precipitation (Inches)	Construction Operation
7	34	24	29.0	T	Grading, Setting Forms, Part 1
8	29	18	23.5	----	" " "
9	32	17	24.5	0.01	Concreting, Part 1
10	35	24	29.5	0.06	Concreting, Part 1
11	36	34	35.0	0.03	Curing Period
12	33	28	30.5	0.02	" "
13	41	21	31.0	----	" "
14	32	16	24.0	----	" "
15	36	23	29.5	0.01	" "
16	32	26	29.0	0.10	" "
17	42	16	29.0	----	" "
18	35	19	27.0	0.03	" "
19	34	29	31.5	0.62	" "
20	36	27	31.5	T	" "
21	37	21	29.0	T	" "
22	36	14	25.0	----	" "
23	24	5	14.5	----	" "
24	28	5	16.5	----	" "
25	25	8	16.5	0.30	" "
26	32	-4	14.0	----	" "
27	35	5	20.0	----	" "
28	40	20	30.0	0.17	" "
29	42	33	37.5	0.59	" "
30	33	18	25.5	0.50	" "
31	31	14	22.5	----	" "
Avg.	35.9	21.0	28.4	Total 2.44	
Feb.					
1	35	21	28.0	0.51	" "
2	38	32	35.0	0.66	" "
3	36	28	32.0	----	" "
4	37	30	33.5	0.11	" "
5	43	25	34.0	----	" "
6	42	36	39.0	0.16	" "
7	46	33	39.5	----	Sealing Joints
8	56	30	43.0	T	Cleaning up
9	46	38	42.0	0.04	" "
10	38	36	37.0	T	" "
11	39	31	35.0	0.44	" "
12	36	33	34.5	0.01	" "
Avg.	41.4	31.1	36.2	Total 1.93	

Despite adverse weather conditions, as evidenced by the above Table I, it is believed that every precaution possible was exercised by the Contractor to secure an adequate pavement. No pavement was placed on frozen subgrade, and it was assured, through thermocouple readings, that the concrete was adequately protected until well beyond the required 14-day curing period.

PART V - INSTRUMENTATION

5.01 GENERAL:

Two types of instruments were installed in the two test tracks, one a Carlson Strain Meter and the other an Aminco Deflection Gage. Both types of gages were similarly located in both tracks so that comparative readings could be taken with respect to each individual track. All gages were installed on the exact centerline of each track and were carefully located by stationing and chaining. Generally, deflection gages were installed in the center of each Item of both tracks. In the plain concrete Items of both tracks, deflection gages were also installed 12 inches from a transverse dummy contraction joint and in the same slab as the center deflection gage. Carlson Strain Meters were installed in the two thickest plain concrete Items of both tracks in another 25 x 25-ft. slab, also at the center of the slab and 12 inches from a

transverse dummy contraction joint. In the case of the Carlson Strain Meters, Meters were installed in the top and bottom of the concrete slab at each location. Locations of all gages are shown on Figure 3 of this report and by the following Tables "J" and "K".

Table "J"

Location and Identification of Gages - Part 1

Gage No.	Function of Gages To Measure	Location		
		Item	Position	Station
DM 51	Deflection at Center	51	℄	0 + 95S
DM 52	Deflection at Center	52	℄	0 + 35S
DM 53	Deflection at Center	53	℄	0 + 25N
DM 54	Deflection at Center	54	℄	0 + 85N
DM 55	Deflection at Center	55	℄	1 + 45N
DM 56	Deflection at Center	56	℄	2 + 03N
DM 57	Deflection at Center	57	℄	2 + 60N
DE 57	Deflection at Edge	57	℄	2 + 71.5N
CET 57	Strain at Top-Edge	57	℄	2 + 73.5N
CEB 57	Strain at Bottom-Edge	57	℄	2 + 73.5N
CMT 57	Strain at Top-Center	57	℄	2 + 85N
CMB 57	Strain at Bottom-Center	57	℄	2 + 85N
DM 58	Deflection at Center	58	℄	3 + 35N
DE 58	Deflection at Edge	58	℄	3 + 46.5N
CET 58	Strain at Top-Edge	58	℄	3 + 48.5N
CEB 58	Strain at Bottom-Edge	58	℄	3 + 48.5N
CMT 58	Strain at Top-Center	58	℄	3 + 60N
CMB 58	Strain at Bottom-Center	58	℄	3 + 60N
DM 59	Deflection at Center	59	℄	4 + 10N
DE 59	Deflection at Edge	59	℄	4 + 21.5N

Table "K"

Location and Identification of Gages - Part 2

Gage No.	Function of Gages To Measure	Location		
		Item	Position	Station
DE 60	Deflection at Edge	60	℄	10 + 51
DM 60	Deflection at Center	60	℄	10 + 62.5
CMT 61	Strain at Top-Center	61	℄	11 + 12.5
CMB 61	Strain at Bottom-Center	61	℄	11 + 12.5
CET 61	Strain at Top-Edge	61	℄	11 + 24
CEB 61	Strain at Bottom-Edge	61	℄	11 + 24
DE 61	Deflection at Edge	61	℄	11 + 26
DM 61	Deflection at Center	61	℄	11 + 37.5
CMT 62	Strain at Top - Center	62	℄	11 + 87.5
CMB 62	Strain at Bottom - Center	62	℄	11 + 87.5
CET 62	Strain at Top-Edge	62	℄	11 + 99
CEB 62	Strain at Bottom-Edge	62	℄	11 + 99
DE 62	Deflection at Edge	62	℄	12 + 01
DM 62	Deflection at Center	62	℄	12 + 12.5
DM 63	Deflection at Center	63	℄	12 + 67.5
DM 64	Deflection at Center	64	℄	13 + 27.5
DM 65	Deflection at Center	65	℄	13 + 87.5
DM 66	Deflection at Center	66	℄	14 + 47.5
DM 67	Deflection at Center	67	℄	15 + 07.5

Although it is intended that the technical function of the above gages will be the subject of a separate report, the following paragraphs briefly describe the procedures of installation and method used to record data.

5.02 CARLSON STRAIN METERS:

These meters were used to measure the static and dynamic strains produced in the plain concrete pavement by the parked and moving test load. Each gage had a 10-inch gage length and was placed to measure tensile and

compressive strain within the concrete to an accuracy of plus or minus five micro-inches per inch. The meters were located in their final position just prior to placement of the concrete by mounting them on 1/4-inch diameter steel rods driven into the subgrade. Meters were mounted in pairs, approximately 1-1/2 inches from the top and bottom of the concrete pavement. The concrete was hand-placed and vibrated around the meters to prevent damage by the finishing machine. Polyethelene-jacketed cable containing twelve conductors, each polyethelene insulated, was used between the meters and the recorders. The cable was run directly into each meter so that no splice was necessary between the transducer and recorder circuit. Cables on Part 1 were run diagonally to the west side of the track on the subgrade and were laid on top the subgrade near the form on the west side of the track, thence extending along the west edge of the track with the form to the north end of the track. Cables on Part 2 were run diagonally to the west side of the track on top of the subgrade and thence along the west edge of the track within the form to the south end of the track. At the end of the curing period, one meter in Part 1 was found inoperative, out of a total of sixteen installed in the two tracks.

5.03 AMINCO DEFLECTION GAGES:

This gage was developed by Laboratory personnel and is produced commercially by the American Instrument Company. All gages were

embedded in the concrete at the time of pouring and are designed to measure dynamic deflections and static subsidence of the pavement to an accuracy of plus or minus .002 of an inch. Their range is 2 inches of movement. Figure 25 shows a typical installation. Reference rods (7/8-inch round steel bars) 10-ft. long, were driven into the subgrade, when final grading was completed, to a point where the top of the rod was 2-inches below grade. Each rod was tapped with a 5/40 hole recessed at the top. A 5-ft. seamless thin-walled steel sleeve of 1-1/2-inch diameter had been mandrelled down first and the reference rod driven through it, the top of the rod and the top of the sleeve being flush. The Aminco deflection gage was set on the subgrade over the reference rod and one gage point screwed into the top of the rod. Gages generally were set so that the maximum deflection of 2 inches could nearly be obtained. Cable identical with that described in the paragraph above, and of sufficient length to reach the recorder, was spliced into the short lead from the Aminco gage. The splices were taped with electrical rubber tape and dipped in melted G-E cable compound to make them waterproof. Cables were stretched diagonally to the inside edge of the forms as described in the paragraph above. During concreting operations, the concrete around the gages was hand-placed and vibrated to prevent damage by the finishing machine. Following curing operations, all gages were checked and out of the 23 Aminco gages installed, 7 were found inoperative,

5 in Part 1 and 2 in Part 2. The extreme wet weather and high water table under Part 1 is believed to have shorted out the gages in Part 1.

5.04 CIRCUITS AND RECORDERS:

A new system of circuits and recorders was developed for this investigation, which will be described in the separate report as previously mentioned. This new recording system was designed to accommodate any type of transducers, to permit a selection of ranges, sensitivities and paper speeds, and to provide direct inked analog data. It has ten channels and any combination of transducers may be connected to any combination of channels. The switching, balancing and rectifying circuits are self-contained plug-in type. The plug-in circuits record the output of Carlson concrete strain meters, magnetic induction gages (Aminco Deflection Gages and Soil Strain Meters) SR-4 gages, and Valore gages. All recording operations are controlled by switches and can be operated by one person. Each channel feeds into a separate Esterline-Angus one milliampere recorder. Cross-connections allow operation of from one to ten recorders simultaneously. A chronograph pen (separate from the data recording pen) in each recorder is connected to pneumatic timing cables laid on the pavement to tie the location of the load rig to the recorded data and time of occurrence.

The entire recording system was installed in a mobile military type trailer, placed between the tracks, so that readings could be taken on

gages in both tracks from one position. A 110 volt, 60 cycle power line was strung on poles and drops were made to the tracks. A photograph of an Aminco Deflection Gage in position for concreting, and the 10-channel recorder housed in the trailer, is shown in the Representative Photographs of the Appendix.

5.05 OTHER INSTRUMENTATION:

a. Thermocouples: In order to observe daily temperatures in the concrete, both during the curing period and the testing period, thermocouples were installed as follows in the top and bottom of the concrete slabs:

Item 61 (Part 2) - 14 inch pavement

Item 63 (Part 2) - 11 inch pavement

Item 54 (Part 1) - 11 inch pavement

Item 59 (Part 1) - 16 inch pavement

Temperatures were read directly, using a standard control box with a wheatstone bridge, and were accurate to $\pm$ 2°F. Air temperatures were obtained from an automatic spring-wound recorder attached to a pole in the immediate vicinity of both tracks.

b. Precise Levels: A Zeiss Opton self-leveling level was made available for this project and was used throughout the construction period with a self-reading level rod to check elevations of forms, subgrade and pavement. Previous experience with this instrument proved that with careful balancing of backsights and foresights, use of a level bubble on the rod, and setting a limit on distances, elevations could be read accurately to .002 of a foot or .024 of an inch.

PART VI - PRE-TRAFFIC PREPARATION

6.01 PAINTING AND STRIPING:

After completion of construction and just prior to traffic load testing, the exact boundaries of each test Item were painted on the pavement, using white traffic paint. Lines were approximately 2-inches wide and were applied using a wood template and mechanical spray gun. Yellow lines were painted throughout the entire length of the track 2-inches wide and 30-inches inside the extreme edges of the track, to indicate the limits of traffic of the outrigger wheels to the operator of the test rig. In order to designate the boundaries for the load wheels of the test rig, a 4-inch white stripe was painted on the track throughout its length and having its inside edge 3.7 inches each side of the centerline of the track. This completed the striping necessary for traffic. In addition, and to facilitate recording and mapping cracks, and taking periodic level readings, 1-1/2-

inch black circles were painted over each gage placed in the test tracks. Longitudinal stationing points were also placed on each side of the tracks, every 10 feet in the reinforced Items, and at all joints and in the centers of all the plain concrete Items.

6.02 CONSTRUCTION OF TRAFFIC RAMPS:

Initially, traffic ramps were constructed at each end of both tracks beginning 12.5-feet back from each end of the tracks. These ramps were approximately 40-feet long and had a slope upward from the pavement of about 1 foot in 15 feet. Their purpose was to allow the Super "C" Tournapull Power Unit a runup grade, permitting a graduated stop so that the load wheels would just halt near the base of the ramp by the slowing down of the Tournapull. Very little braking action was thus necessary on the part of the operator. These ramps were built by government forces and were composed of stabilized sand and gravel topped by a sand layer to prevent damage to tires. Considerable hand-shovel work was required in the initial stages of operation until the ramps became stabilized.

6.03 TRAFFIC TESTING EQUIPMENT:

The traffic testing equipment consisted of two identical test rigs joined together back to back by a rigid coupling which allowed only slight sidewise motion and limited vertical motion. Each load assembly consisted

of a load box, a load beam, two 56 x 16-inch aircraft tires mounted on steel wheels and axle, a Super "C" Tournapull power unit and a stabilizing yoke. The load box and yoke were originally constructed by the American Bridge Company, Pittsburgh, Pennsylvania. The load beam, steel wheels and axle, and rigid coupling, were constructed by the Equipment Branch of the Ohio River Division Laboratories. The 56 x 16-inch tires and tubes were obtained from the Wright Air Development Center, Dayton, Ohio. Assembly and tire and rig maintenance was performed by the Traffic Tests Section of the Ohio River Division Laboratories. Inflation pressures of 185 psi were used on all load rig tires, providing a contact area of 267 square inches under each tire. Photographs of the loading assembly are contained in the Representative Photographs of the Appendix.

PART VII - EVALUATION OF TEST SECTIONS

7.01 GENERAL:

This section of this report is concerned primarily with evaluations of only the subgrade and concrete properties. Evaluations of traffic life, effects of reinforcement, and effectiveness of a filter base will be made in the Final Report for this project.

7.02 SUBGRADE:

a. Part 1: From Figure 4 of this report, it can be seen that two

types of material compose the subgrade for this track; namely, a Fat Clay (CH) and a Sandy or Lean Clay (CL). Inasmuch as both types of material are considered "borderline" materials between a fat and lean clay, it is recommended that the subgrade of Items 51 through 56 be considered as being a Lean Clay (CL-CH). Items 57 and 58 are both underlain by a deep deposit of Fat Clay (CH) whose properties definitely place it in that grouping. Item 59 is underlain by a Sandy Clay (CL), which again is definitely grouped into this classification by its properties.

From Figure 7, subgrade modulus values further support the recommendations made above, in that Items 51 through 56 have "k" values confined between 44 and 52, Items 57 and 58 have values of 27 and 30, and Item 59 has a "k" value of 47.

Because of unfavorable weather conditions which generally exist in this climate at the time of construction, the subgrade was considerably wetter than desirable. Unit dry weights for the material under Items 51 through 56 ranged from 90.8 lbs/ft^3 to 99.4 lbs/ft^3, with water contents of 25.4 percent to 30.0 percent. All subgrade material was either at or wetter than its plastic limit, and the percent of Modified AASHC Density was approximately 83.

Summarizing, it is recommended that the following subgrade values be used in analysis of performance of the Items in Part 1 until verified by after traffic tests.

Items	Type of Subgrade	Subgrade Modulus	(Percent) Mod. AASHO Density
51-56	Lean Clay (CL-CH)	50	82
57, 58	Fat Clay (CH)	30	84
59	Sandy Clay (CL)	50	89

b. Part 2: As can be seen from Figure 5, the subgrade beneath this track was both prepared and natural, the emphasis in this track being to obtain a "k" of 300 lbs/in^{2}in. regardless of the type of material used. Generally the original subgrade was a Silty Sandy Gravel (GM_d) and was left in its natural state under Items 61, 64, 65 and 66. Under Items 62, 63 and 67, the subgrade was a prepared mixture consisti[illegible] of crushed stone and gravel, topped by a stabilized base material. Thicknesses of this material varied from 6 inches to 30 inches under Items 62 and 63, and was less than 12 inches in Items 60 and 67. As can be seen from Figure 21, the prepared subgrade yielded higher "k" values in the deeper sections than those obtained both from the natural material and the prepared material less than 12 inches in thickness. Summarizing from the above discussion and from Figures 5 and 21, the following subgrade values are recommended for use in analysis of performances of the Items in Part 2 until verification by after traffic tests.

Items	Type of Subgrade	Subgrade Modulus	(Percent) Mod. AASHO Density
60, 61, 64 65, 66	Silty Sandy Gravel (GM_d)	320	97.7
62, 63	Prepared Gravel-Stone Base (GW)	370	86.5
67	Silty Sandy Gravel (GM_d)	300	93.2

7.03 CONCRETE:

a. General: All aggregate, cement, water, air-entraining admixtures and methods of batching and delivery were the same on both test tracks, with exception of the addition of 1/2 bag of cement per cubic yard in Part 1. Consequently it is believed that fairly uniform strengths were obtained from the concrete placed in each track.

b. Part 1: As can be seen from Table "G", all the concrete contained in Items 51 through 58 was a 6-bag mix. It is therefore recommended that the average strengths shown for the 6-bag mix be considered as representative of all the concrete in the above mentioned Items, which are as follows:

Items 51 through 58*

Flexural Strength (90 day):	740 psi
Static "E" (90 day):	4.08×10^6
Dynamic "E" (90 day):	5.91×10^6
Density:	148.6 lbs/ft^3
Air Entrainment:	4.4 percent
Slump:	3 inches

*Item 59 included in Part 2

c. Part 2: A 5-1/2 bag mix was used in Part 2, and in 75 percent of Item 59 in Part 1. Referring to Tables "H" and "G", the following average values are recommended for use in analyzing traffic performance of all Items of Part 2, and Item 59 of Part 1:

Items 60-67 and Item 59

Flexural Strength (90 day):	730 psi
Static "E" (90 day):	4.43×10^6
Dynamic "E" (90 day):	5.90×10^6
Density:	149.6 lbs/ft^3
Air-Entrainment:	4.6 percent
Slump:	3-1/4 inches

d. Pavement Thicknesses: Following the curing period for the concrete in both tracks, precise levels were run over both tracks on 10-foot ranges in the reinforced Items and on 12-1/2-foot ranges in the plain concrete Items. Inasmuch as traffic testing will be concerned primarily with the center 7.4-foot width of each track, a longitudinal profile was developed which defined closely the actual pavement thicknesses in this area. From this profile, which is shown on Figure 26, and tempered with field notes which indicated the irregularities in form elevations, (however, within tolerances) the following is recommended as actual pavement thickness for future analysis of performance of the Items:

Table "L"

Comparison Between Design Thickness and Actual Thickness of Items

Item	Design Thickness	Actual Thickness	Item	Design Thickness	Actual Thickness
	Part 1			Part 2	
51	11.0"	11.0"	60	12.0"	11.7"
52	11.0"	11.0"	61	14.0"	14.0"
53	11.0"	11.0"	62	16.0"	15.8"
54	11.0"	11.0"	63	11.0"	10.8"
55	14.0"	14.25"	64	11.0"	10.7"
56	14.0"	14.1"	65	8.0"	7.7"
57	20.0"	20.0"	66	8.0"	7.8"
58	18.0"	18.0"	67	8.0"	7.9"
59	16.0"	16.0"			

PART VIII - SUMMARY AND CONCLUSIONS

8.01 GENERAL:

The construction of the test tracks was accomplished during a particularly bad season of the year, when freezing weather and heavy precipitation in the form of snow and rain occurs. Despite these conditions, it is concluded that the construction was completed within the full intent, and to the general satisfaction of the plans and specifications. Considerable extra expense was borne by the Contractor in the form of protective devices against freezing weather, which would have been unnecessary had construction been scheduled for the summer months. However, the urgency for data to be obtained from this study, made construction in this period necessary.

8.02 PART 1:

The following is concluded and summarized with respect to Part 1, which is the track constructed on a low bearing value subgrade:

a. The subgrade is of three distinct types; a Fat Clay (CH) material which exists under the 18 and 20-inch plain concrete Items; a Sandy Clay (CL) material which exists under the 16-inch plain concrete Item; and a borderline Lean-Fat Clay (CL-CH) material which exists under all reinforced Items. With exception of the Sandy Clay, which was compacted to approximately 90 per cent of Modified AASHO

Density, all subgrade was compacted to slightly less than 85 per cent of Modified AASHO Density. (See Paragraph 7.02 a.)

b. Subgrade modulus values, obtained from plate bearing tests, indicated a fairly uniform value of 50 lbs/in^3 for the Sandy Clay (CL) and borderline Lean Clay-Fat Clay (CL-CH) material and a value of 30 lbs/in^3 for the Fat Clay (CH) material (See Paragraph 7.02 a.)

c. The 90-day flexural strength tests on laboratory cured beams (6-bag mix) were very uniform and the average strength of 740 psi is recommended for use in future analysis of performance of Items 51 through 58. (See Paragraph 7.03 b.)

d. The concrete in Item 59 (5-1/2-bag mix) is representative of the concrete in all of Part 2, and the average strength of 730 psi is recommended for use in future analysis of performance of this Part. (See Paragraph 7.03 c.)

e. Pavement thicknesses in all Items were either at or greater than design thickness. Only the 14-inch Items 55 and 56 were thicker than design thicknesses, Item 55 being 14.25 inches and Item 56 being 14.1 inches. (See Table "L", Paragraph 7.03 d.)

8.03 PART 2:

The following is concluded with respect to Part 2, which is the track constructed on a high bearing value subgrade:

a. The subgrade of this track in original state, was a Silty Sandy Gravel (GM_d). Soft spots, which caused the subgrade to weave under proof-rolling under Items 62 and 63 were replaced with a prepared Gravel-Stone base (GW) material, which provided the complete track with a fairly uniform subgrade, bearingwise at least. Compaction of the natural material yielded density values of approximately 95 per cent of Modified AASHO Density, while the prepared Gravel-Stone base was placed at slightly more than 85 per cent of Modified AASHO Density. (See Paragraph 7.02 b.)

b. Subgrade modulus values obtained from plate bearing tests, and corrected for bending of the plate, indicated a value between 300 and 320 lbs/in^3 for the natural material, and a value of 370 lbs/in^3 for the prepared Gravel-Stone base. (See Paragraph 7.02 b.)

c. The 90-day flexural strength tests on laboratory-cured beams (5-1/2-bag mix) were again very uniform and the average strength of 730 psi is recommended for use in future analyses of performance of Items in this track. (See Paragraph 7.03 c)

d. Pavement thicknesses in this track were with one exception all less than design thickness. The 14-inch plain concrete Item was at its design thickness; other Items were 0.1" to 0.3" less than design thickness. (See Table "L", Paragraph 7.03 d.)

Corps of Engineers U. S. Army

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

FIGURES

Ohio River Division Laboratories
Mariemont, Ohio

March 1957

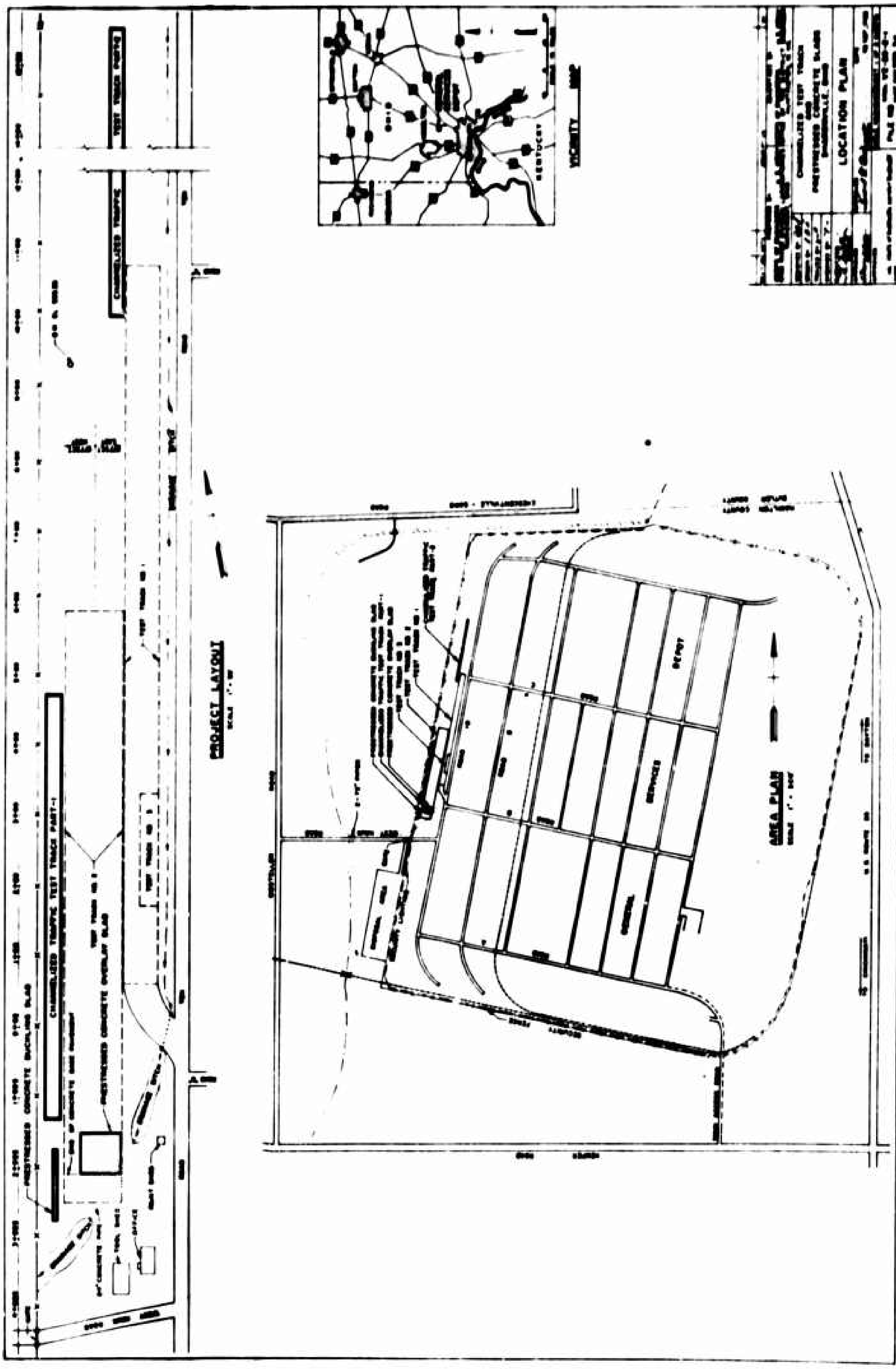


FIGURE 1

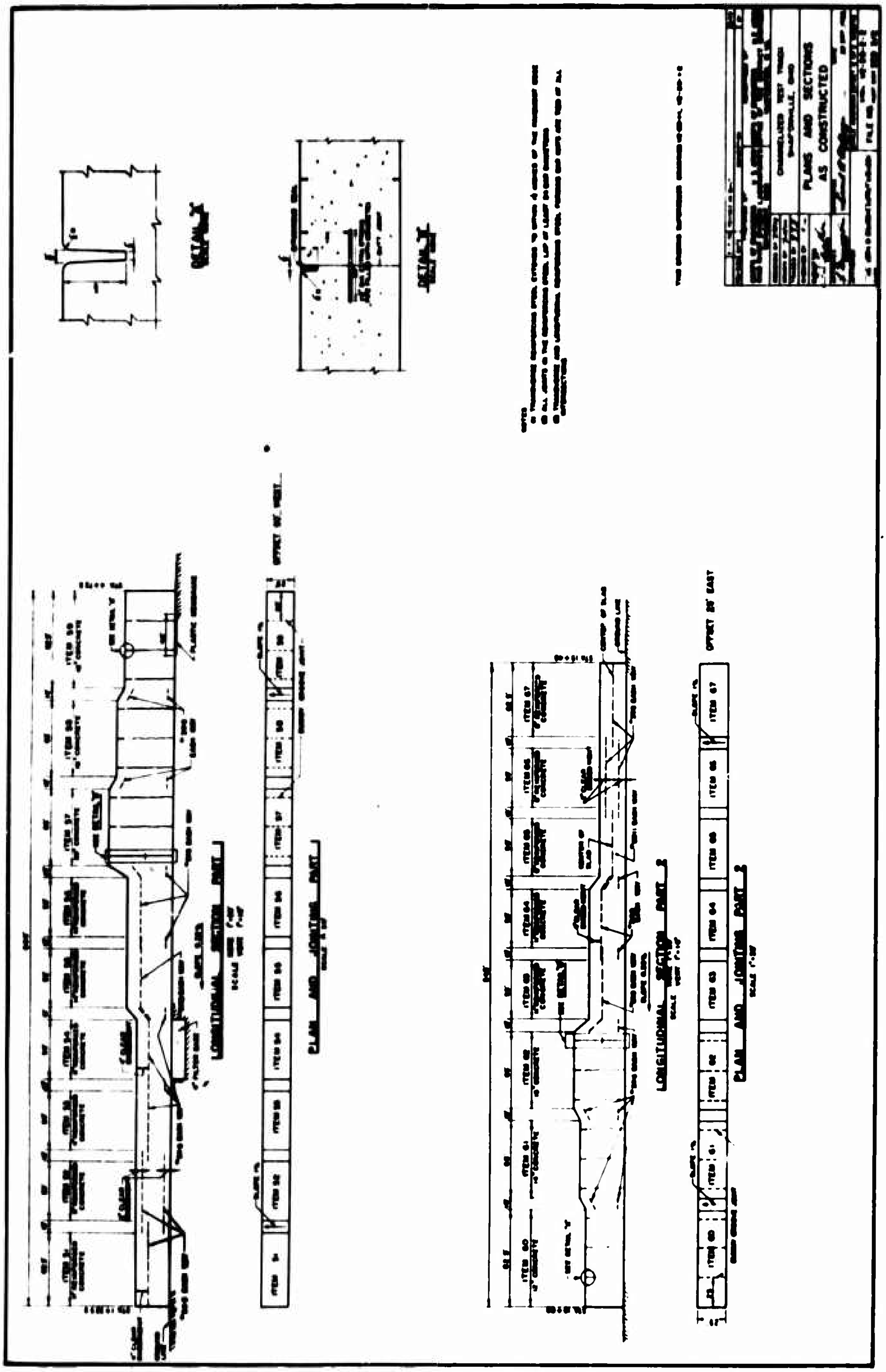

LONGITUDINAL SECTION PART 1
PLAN AND JOINTING PART 1
LONGITUDINAL SECTION PART 2
PLAN AND JOINTING PART 2
OFFSET 20' EAST
DETAIL "X"
DETAIL "Y"
PLANS AND SECTIONS
AS CONSTRUCTED

FIGURE 2

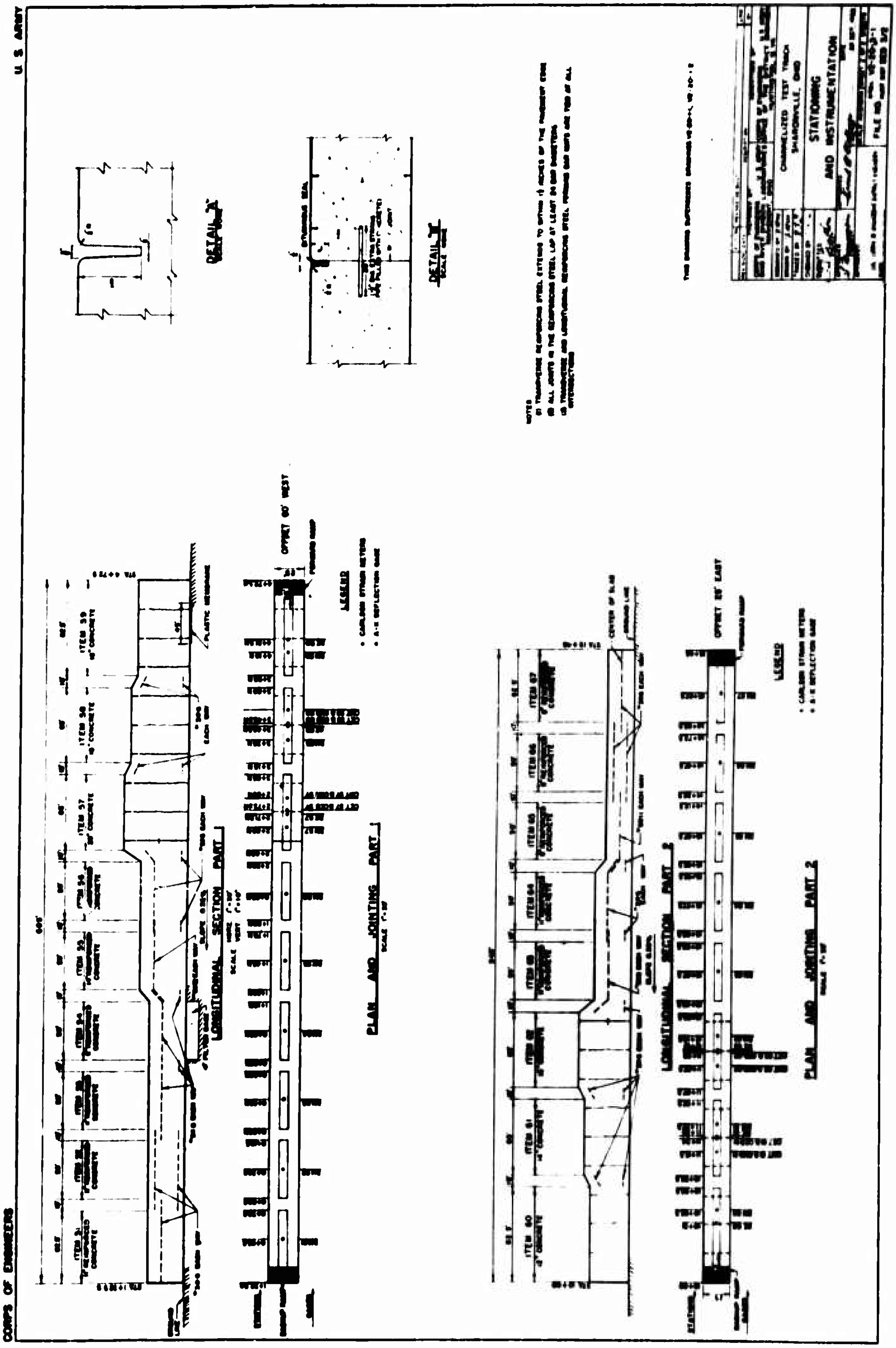
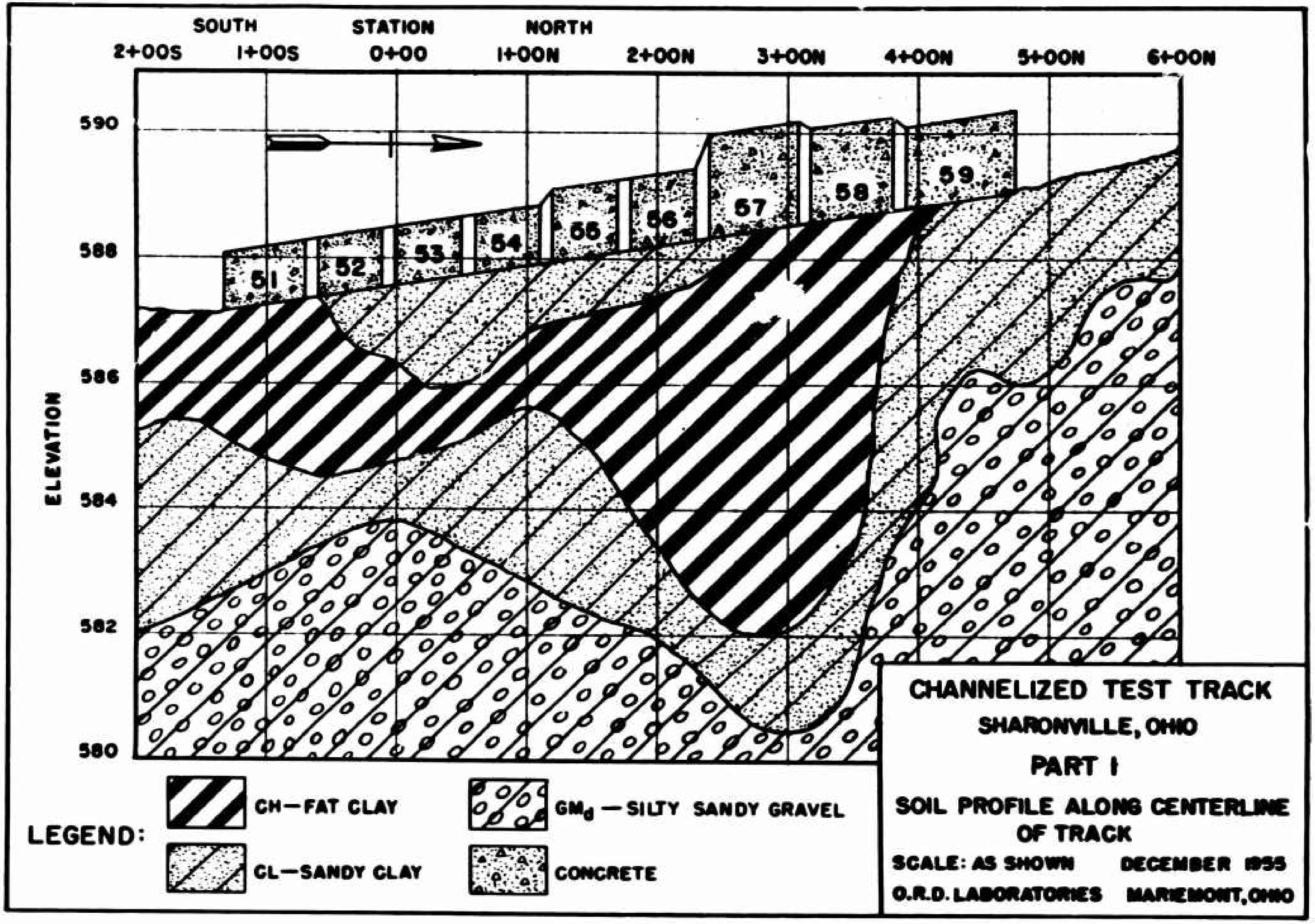

CORPS OF ENGINEERS
U S ARMY
LONGITUDINAL SECTION PART 1
PLAN AND JOINTING PART 1
LONGITUDINAL SECTION PART 2
PLAN AND JOINTING PART 2
OFFSET 60' WEST
OFFSET 20' EAST
LEGEND
STATIONING AND INSTRUMENTATION

FIGURE 3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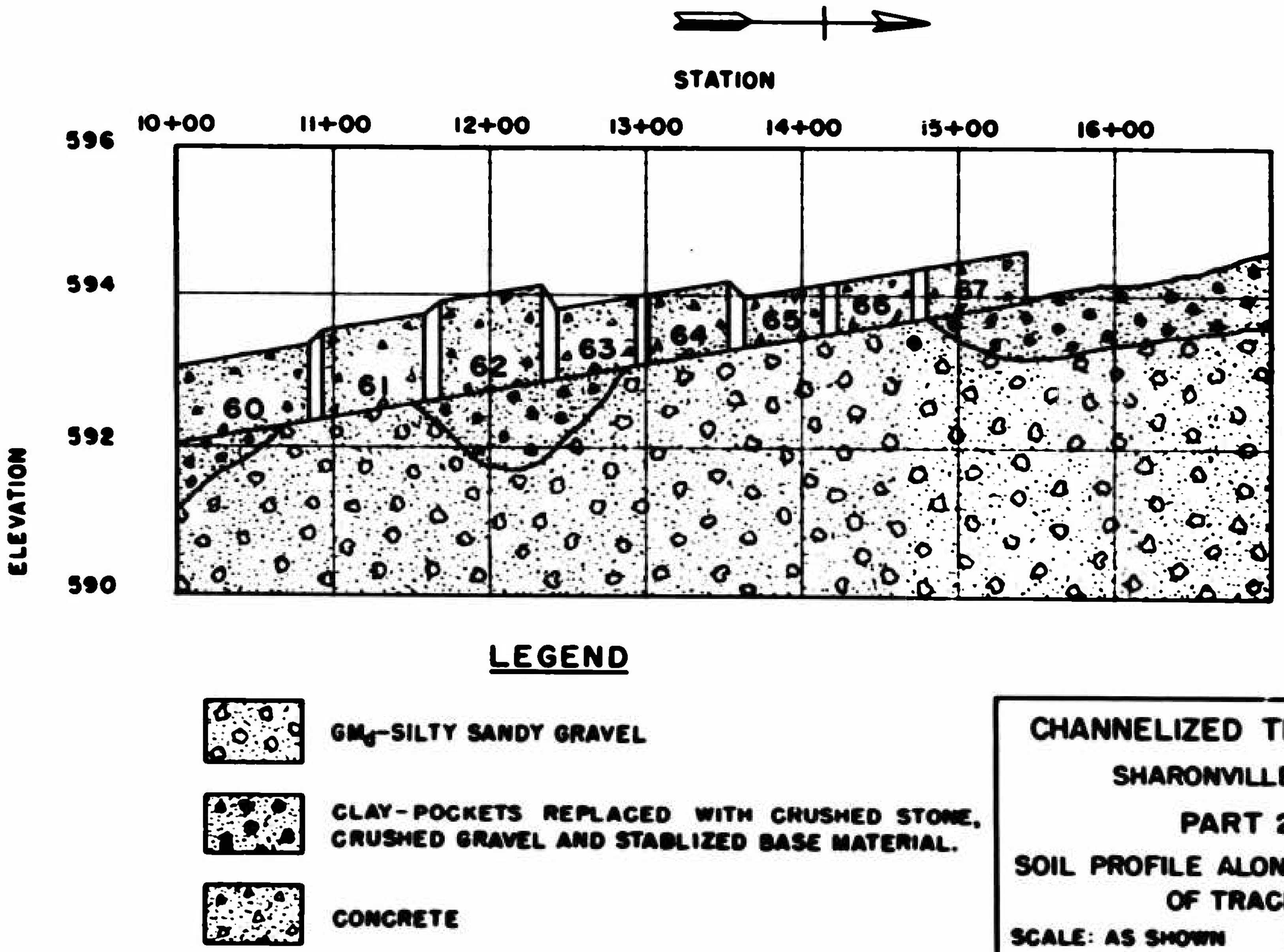
STATION
NORTH
2+00S
1+00S
0+00
1+00N
2+00N
3+00N
4+00N
5+00N
6+00N
ELEVATION
590
588
586
584
582
580
51
52
53
54
55
56
57
58
59
LEGEND:
CH—FAT CLAY
GL—SANDY CLAY
GM_d — SILTY SANDY GRAVEL
CONCRETE
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART I
SOIL PROFILE ALONG CENTERLINE OF TRACK
SCALE: AS SHOWN
DECEMBER 1955
O.R.D. LABORATORIES
MARIEMONT, OHIO

FIGURE 4



CHANNELIZED TEST TRACK

SHARONVILLE, OHIO

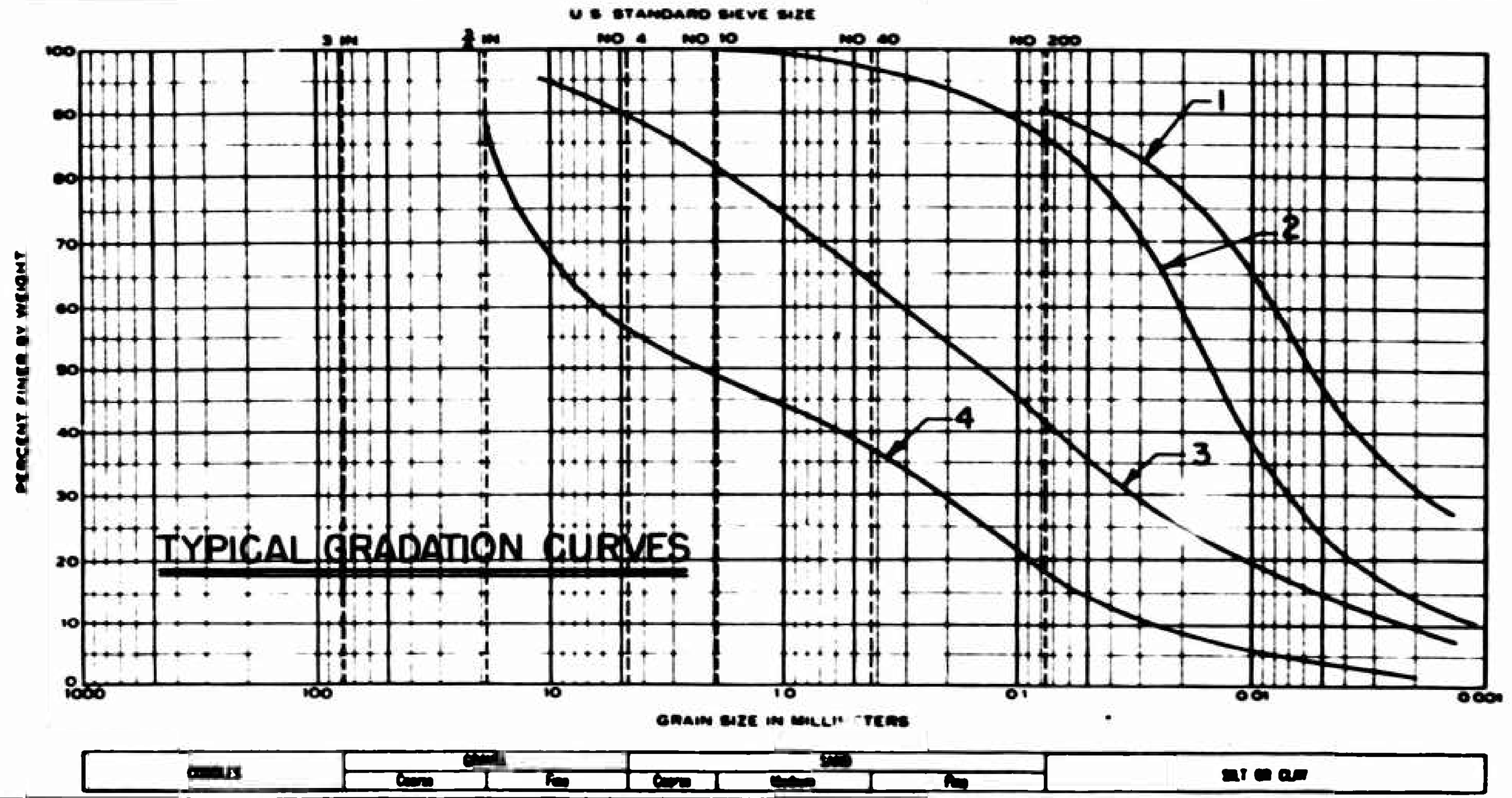
PART 2

SOIL PROFILE ALONG CENTERLINE OF TRACK

SCALE: AS SHOWN   DECEMBER 1955

O.R.D. LABORATORIES   MARIEMONT, OHIO

FIGURE 5



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	
1	587.1	Dk Gray Fat CLAY (CH)	25.9	61.7	26.5	35.2	ITEM 57
2	587.0	Gr br Lean CLAY (CL)	36.6	49.6	23.6	26.0	ITEM 53
3	587.0	Gr Sandy CLAY (CL)	21.4	26.8	17.7	9.1	ITEM 59
4	581.0	Br Silty, Sandy GRAVEL (GM_d)	7.1	23.3	20.0	3.3	ITEM 51

GRADATION CURVES

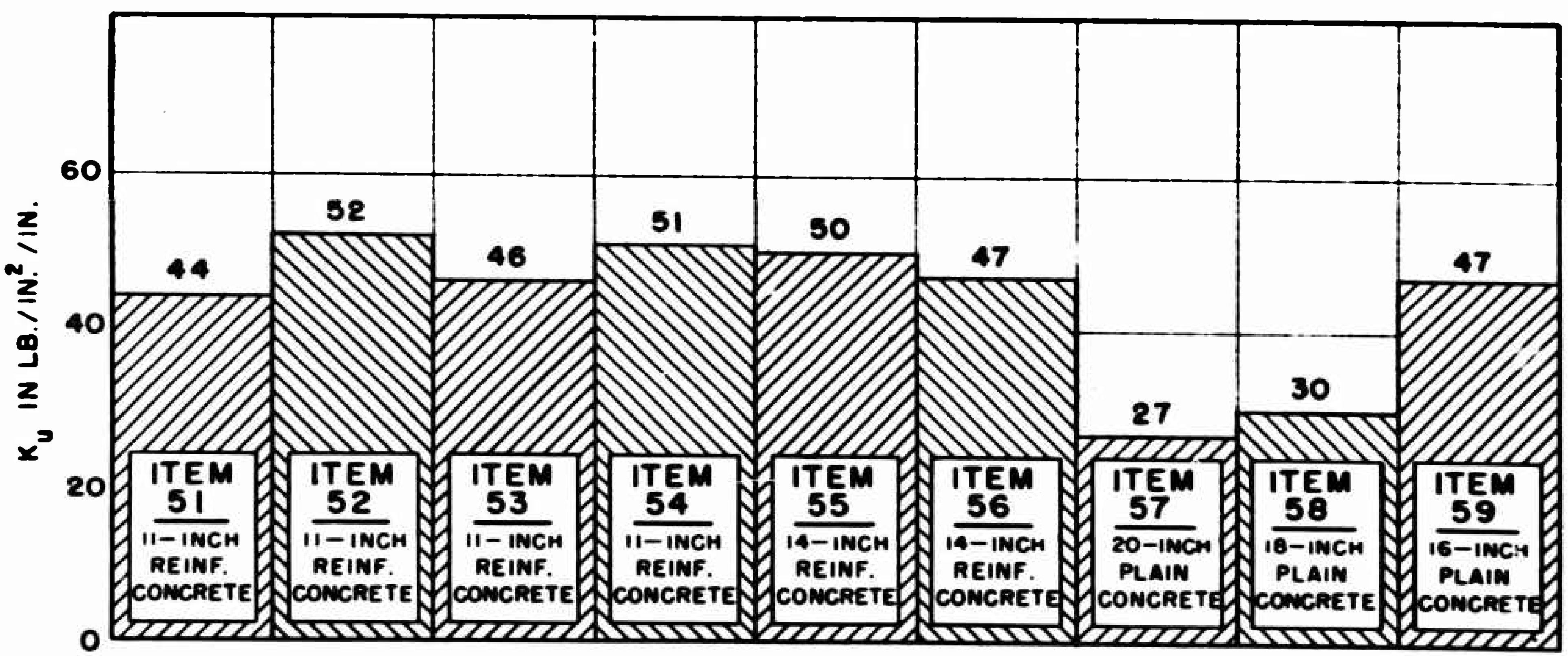
Project CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
Area PART I
Boring No. SUBGRADE MATERIAL
Date JANUARY 1956

FIGURE 6

CHANNELIZED TEST TRACK
SHARONVILLE, OHIO

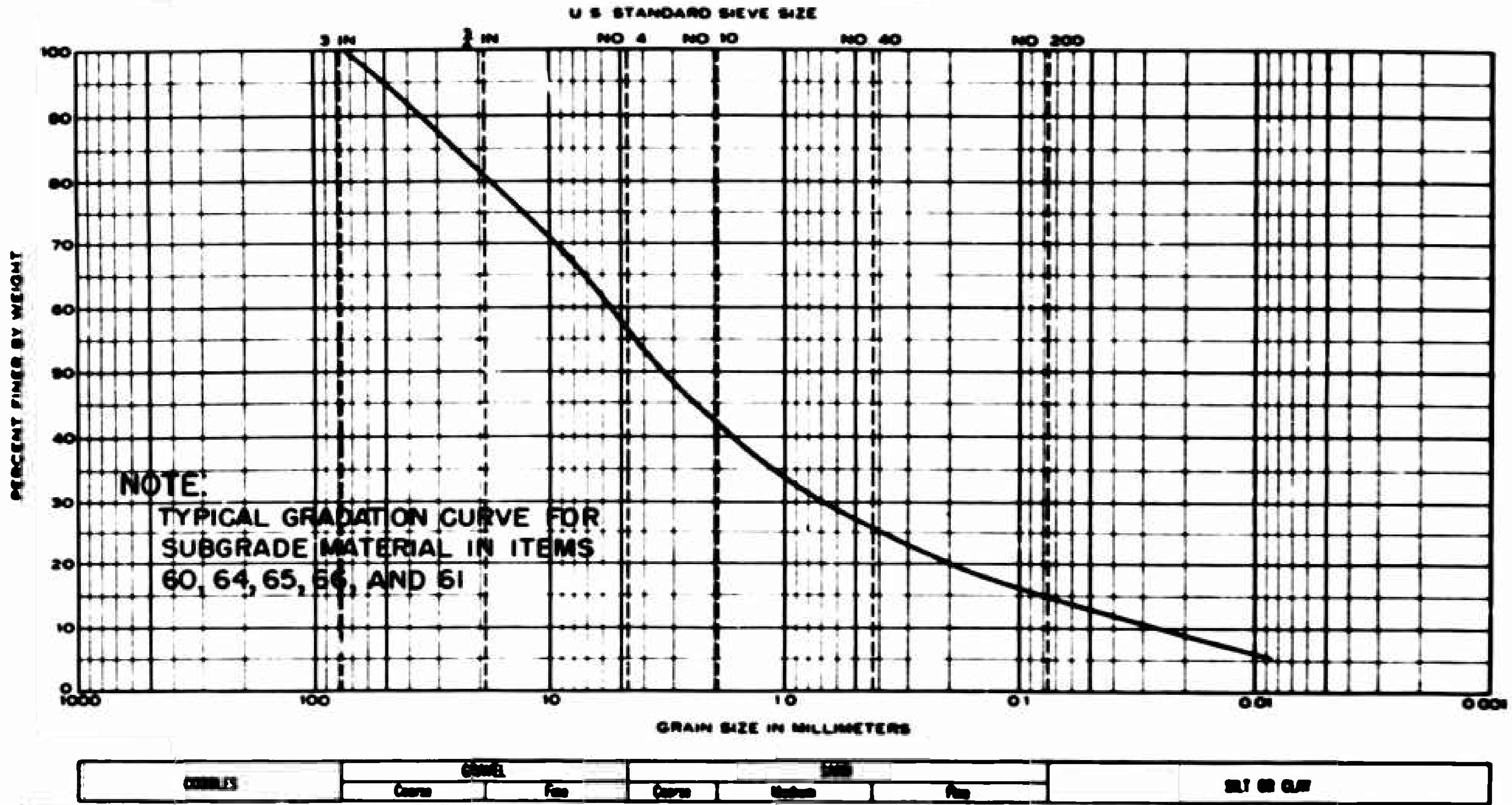
PART I

SUMMARY OF ESTABLISHED SUBGRADE MODULUS VALUES



JANUARY 1956

FIGURE 7

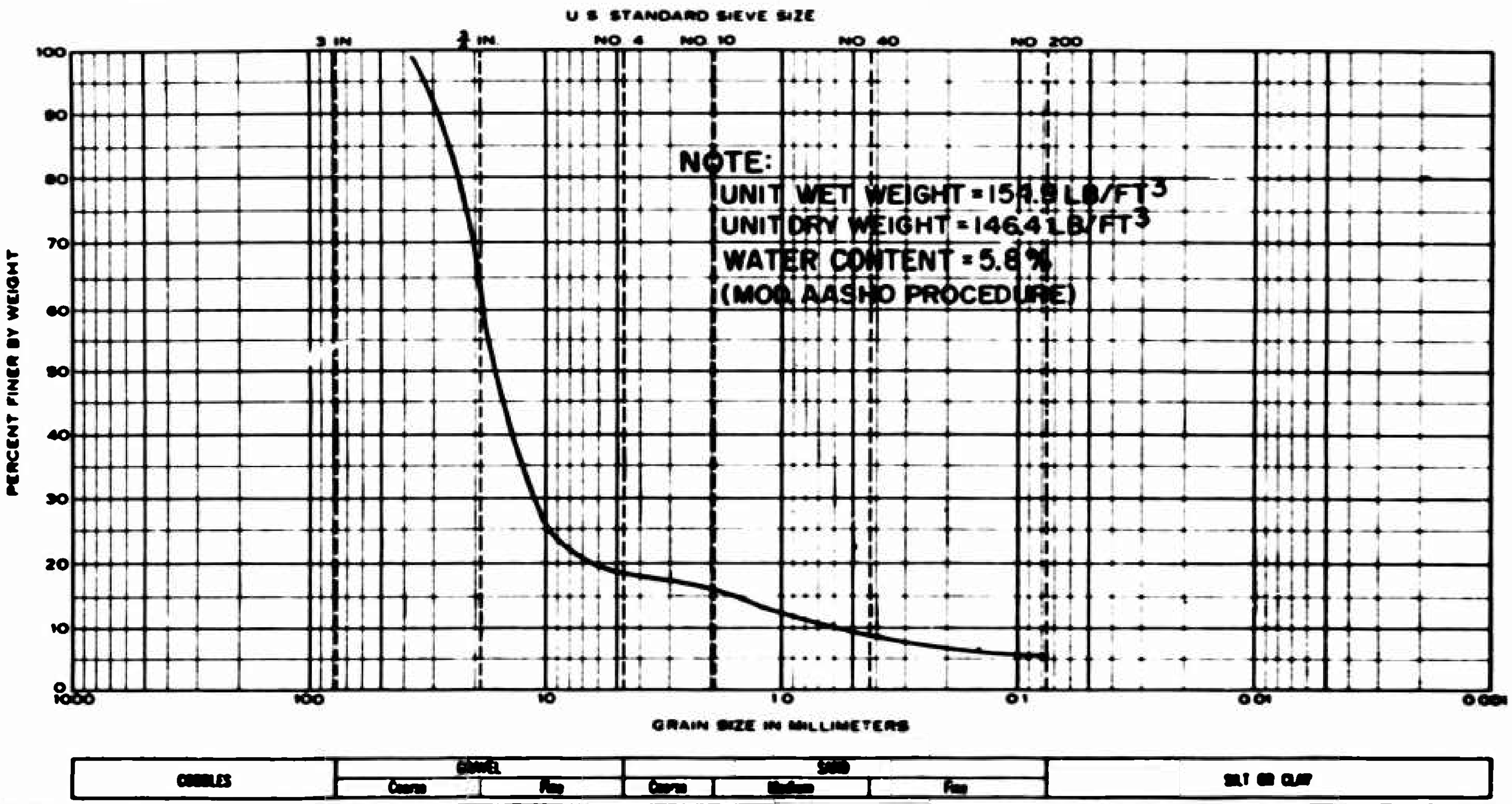


Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	
		Br Silty Sandy GRAVEL (GM_d)	7.1	23.3	20.0	3.3	

GRADATION CURVES

Project CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
Area PART 2
Boring No.
Date DECEMBER 1955

FIGURE 8

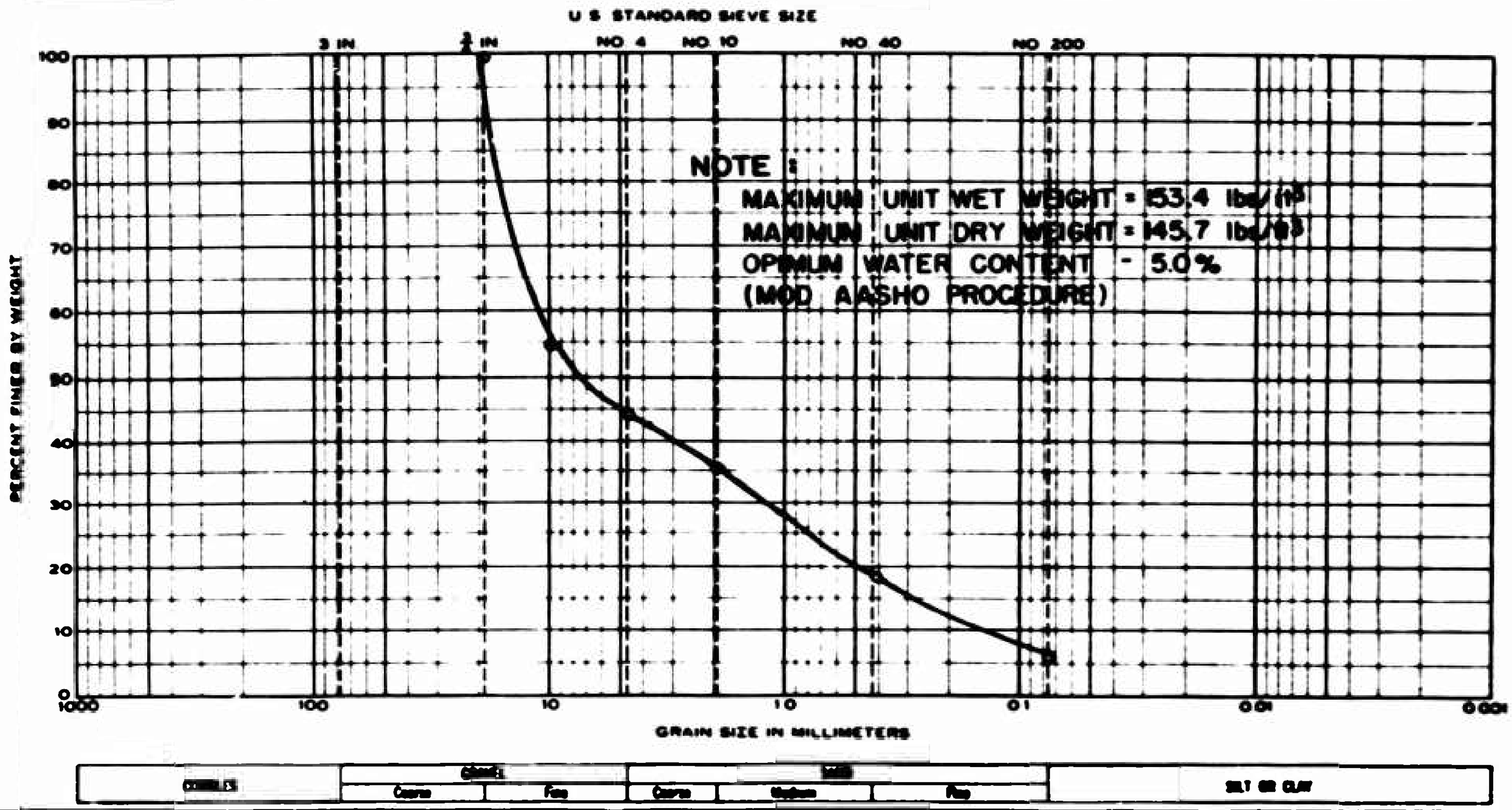


Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	

GRADATION CURVES

Project CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
Area PART 2
Boring No. CRUSHED GRAVEL USED TO STABILIZE WEAK SECTIONS
Date DEC 1955

FIGURE 9



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	

Project CHANNELIZED TEST TRACK

SHARONVILLE, OHIO

Area PART 2

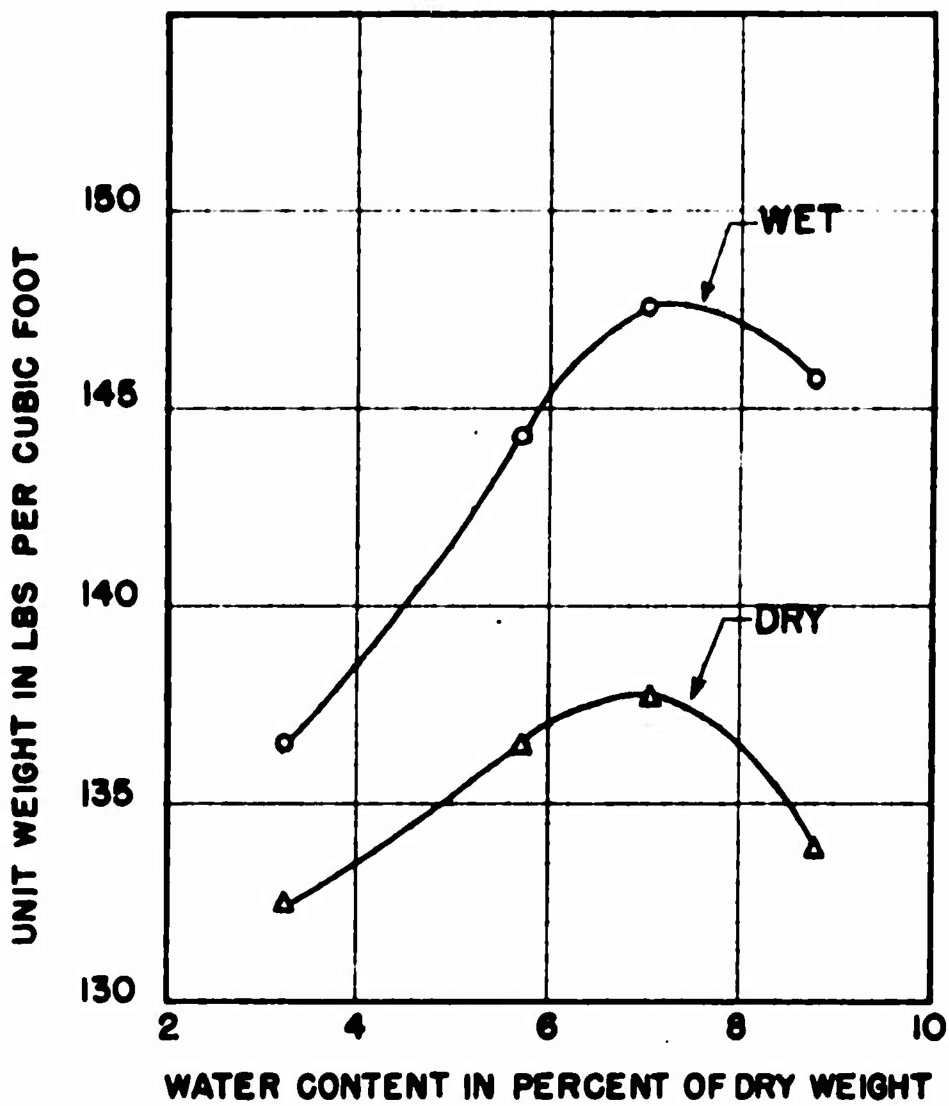
Boring No. STABILIZED BASE MATERIAL USED TO TOP CRUSHED GRAVEL

Date DECEMBER 1955

GRADATION CURVES

FIGURE 10

MODIFIED AASHO MOISTURE—DENSITY CURVE ON GM_d MATERIAL PRESENT IN ITEMS 60,64,65,66 AND 61.



CHANNELIZED TEST TRACK

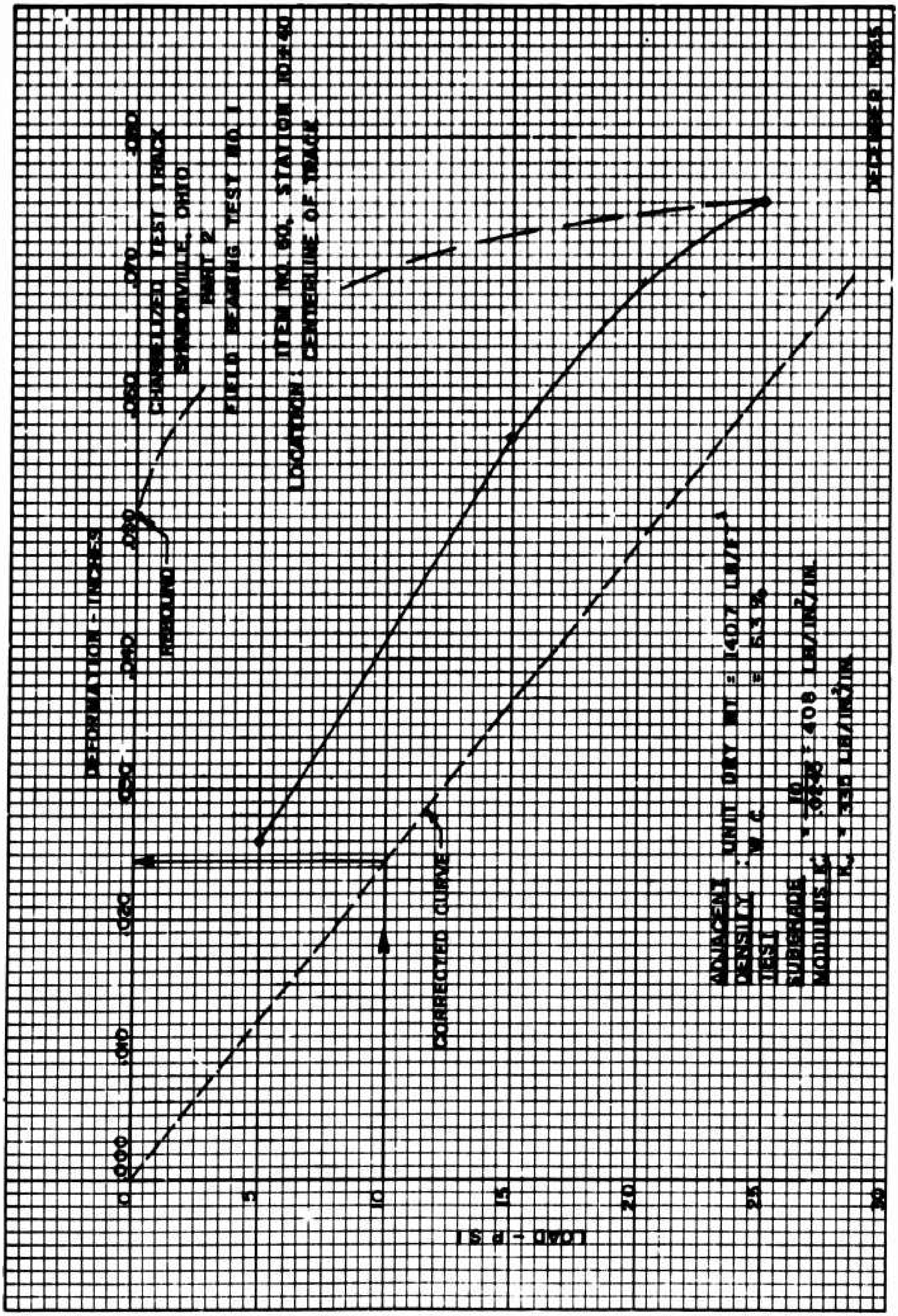
SHARONVILLE, OHIO

PART 2

OHIO RIVER DIVISION LABORATORIES MARIEMONT, OHIO

DECEMBER 1955

FIGURE 11



DEFORMATION - INCHES
.000
.010
.020
.030
.040
.050
.060
.070
.080
LOAD - P S I
0
5
10
15
20
25
30
REBOUND
CORRECTED CURVE
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO. 1
LOCATION: ITEM NO. 60, STATION 10+40
CENTERLINE OF TRACK
ADJACENT UNIT DRY WT = 140.7 LB/FT³
DENSITY W.C = 5.3 %
TEST
SUBGRADE MODULUS K = 10/.0245 = 408 LB/IN²/IN
K_u = 335 LB/IN²/IN
DECEMBER 1955

FIGURE 12

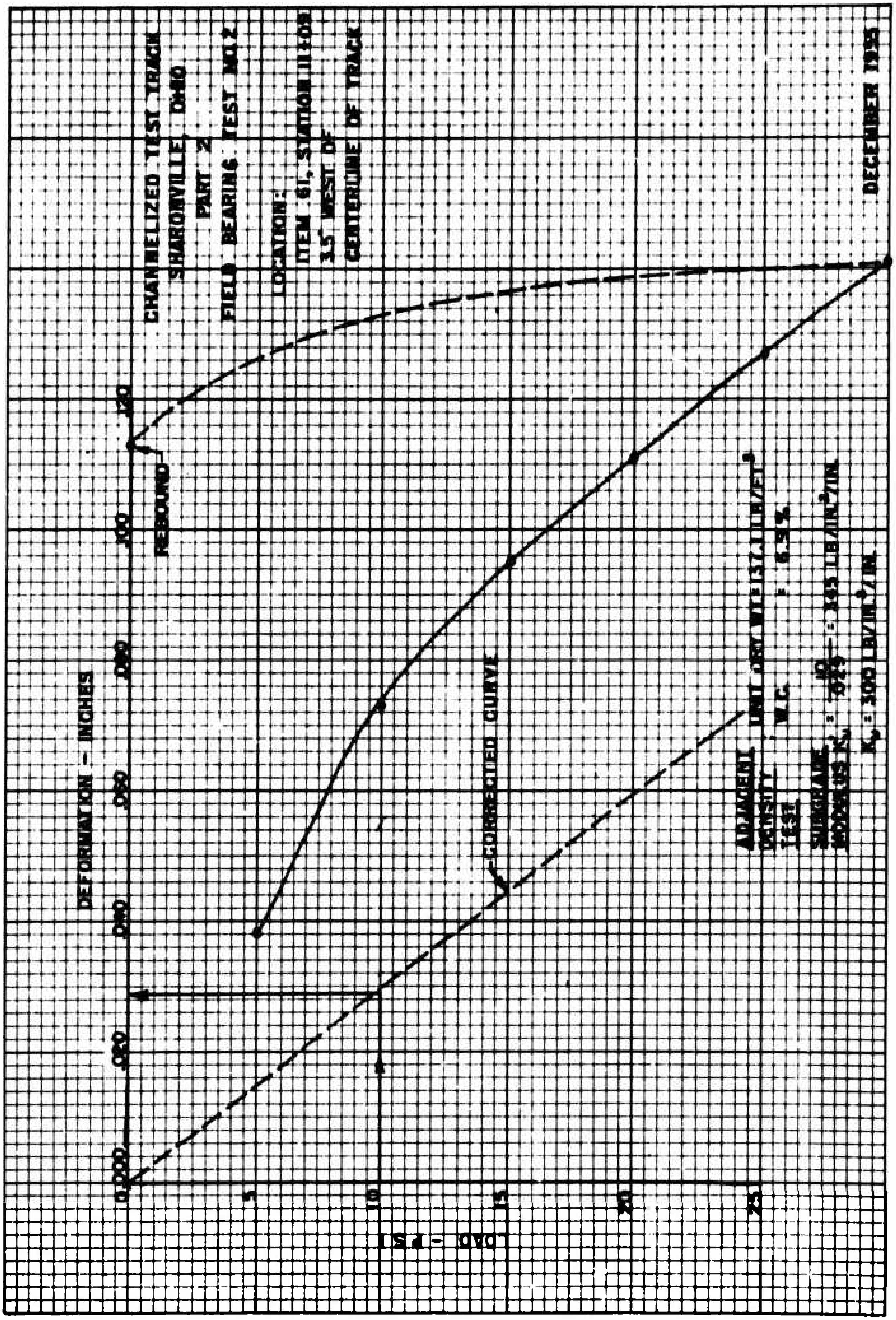
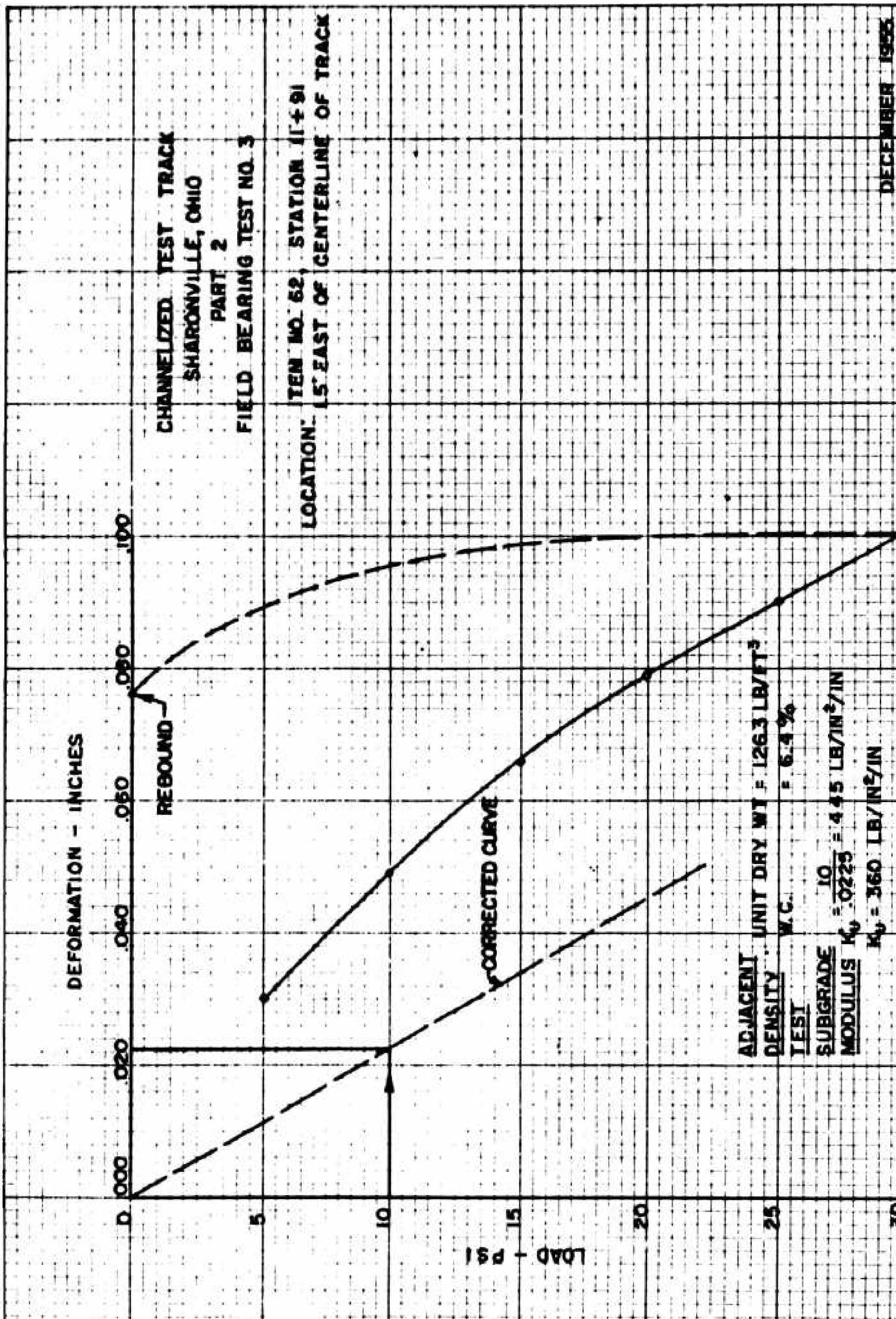

CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO. 2
LOCATION:
ITEM 61, STATION 11+08
3.5' WEST OF
CENTERLINE OF TRACK
DECEMBER 1955
DEFORMATION - INCHES
0.000
.020
.040
.060
.080
.100
.120
REBOUND
CORRECTED CURVE
LOAD - PSI
5
10
15
20
25
ADJACENT DENSITY TEST
UNIT DRY WT
W.C.
SUBGRADE MODULUS

FIGURE 13



DEFORMATION - INCHES
0 .000 .020 .040 .060 .080 .100
LOAD - PSI
0 5 10 15 20 25 30
REBOUND
CORRECTED CURVE
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO. 3
LOCATION: TEN NO. 62, STATION 11+91
1.5' EAST OF CENTERLINE OF TRACK
ADJACENT DENSITY TEST
UNIT DRY WT = 126.3 LB/FT3
W.C. = 6.4 %
SUBGRADE MODULUS
Ku = 10 / .0225 = 445 LB/IN2/IN
Ku = 360 LB/IN2/IN
DECEMBER 1955

FIGURE 14

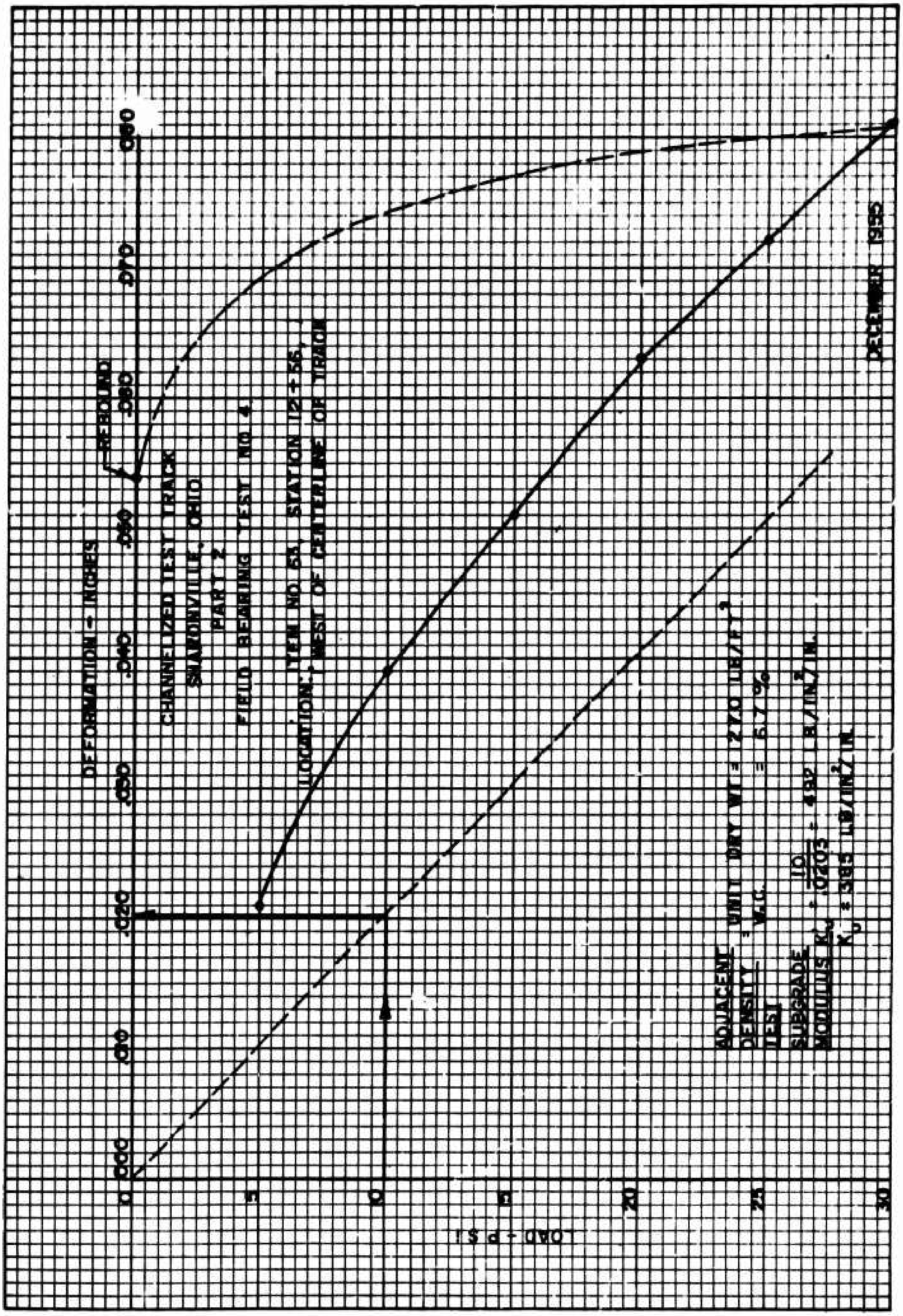

DEFORMATION - INCHES
.000
.010
.020
.030
.040
.050
.060
.070
.080
REBOUND
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO 4
LOCATION: ITEM NO 63, STATION 112+56,
1' WEST OF CENTERLINE OF TRACK
ADJACENT DENSITY TEST: UNIT DRY WT = 27.0 LB/FT³
W.C. = 6.7 %
SUBGRADE MODULUS K_u = $\frac{10}{.0203}$ = 492 LB/IN²/IN.
K_u = 385 LB/IN²/IN.
DECEMBER 1955
LOAD - P S I
0
5
10
15
20
25
30

FIGURE 15

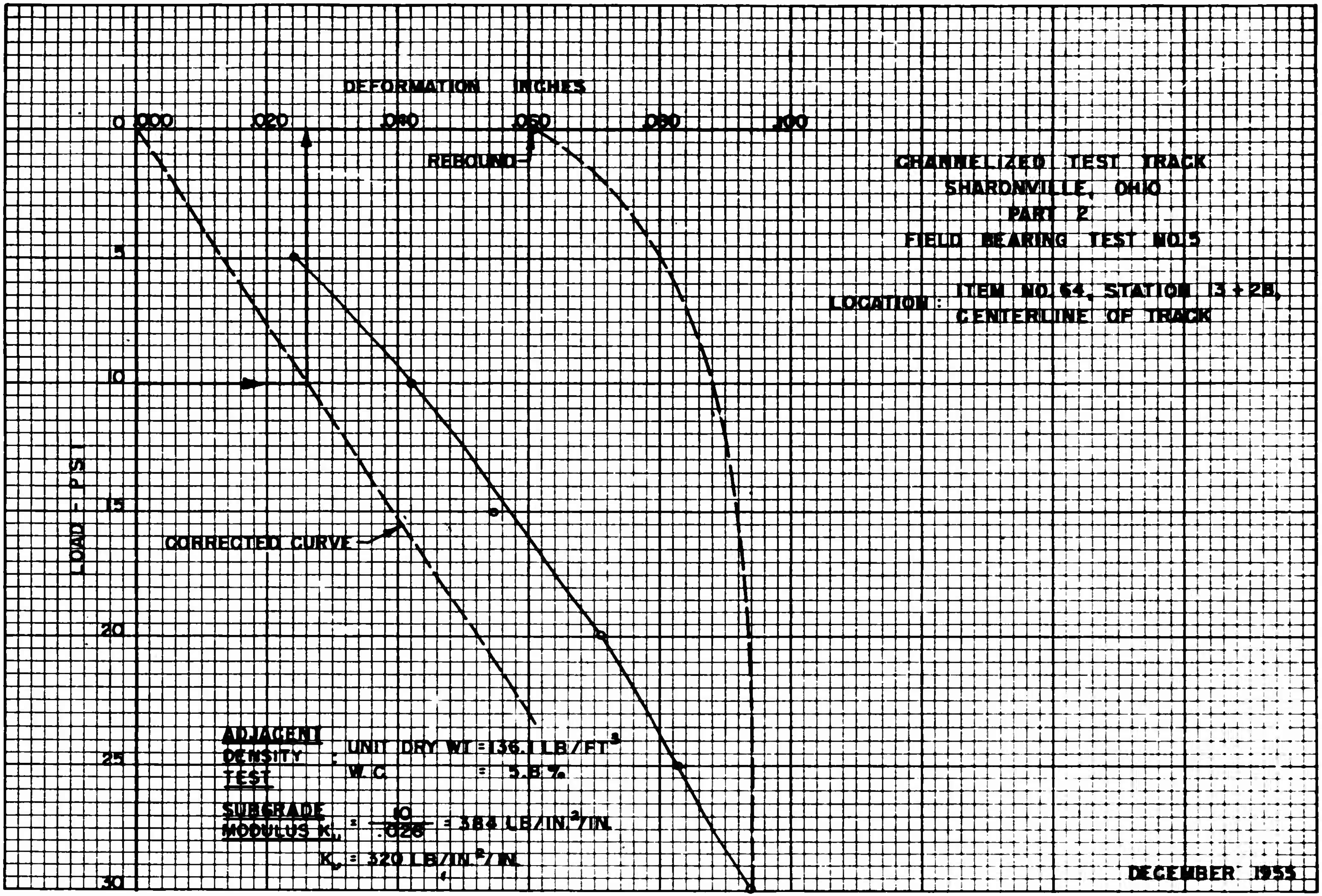

DEFORMATION INCHES
0 .000
.020
.040
.060
.080
.100
REBOUND
5
10
15
20
25
30
LOAD - PSI
CORRECTED CURVE
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO. 5
LOCATION : ITEM NO. 64, STATION 13 + 28,
CENTERLINE OF TRACK
ADJACENT DENSITY TEST : UNIT DRY WT = 136.1 LB/FT³
W. C = 5.8 %
SUBGRADE MODULUS K, = 10/.026 = 384 LB/IN.²/IN.
K = 320 LB/IN.²/IN.
DECEMBER 1955

FIGURE 16

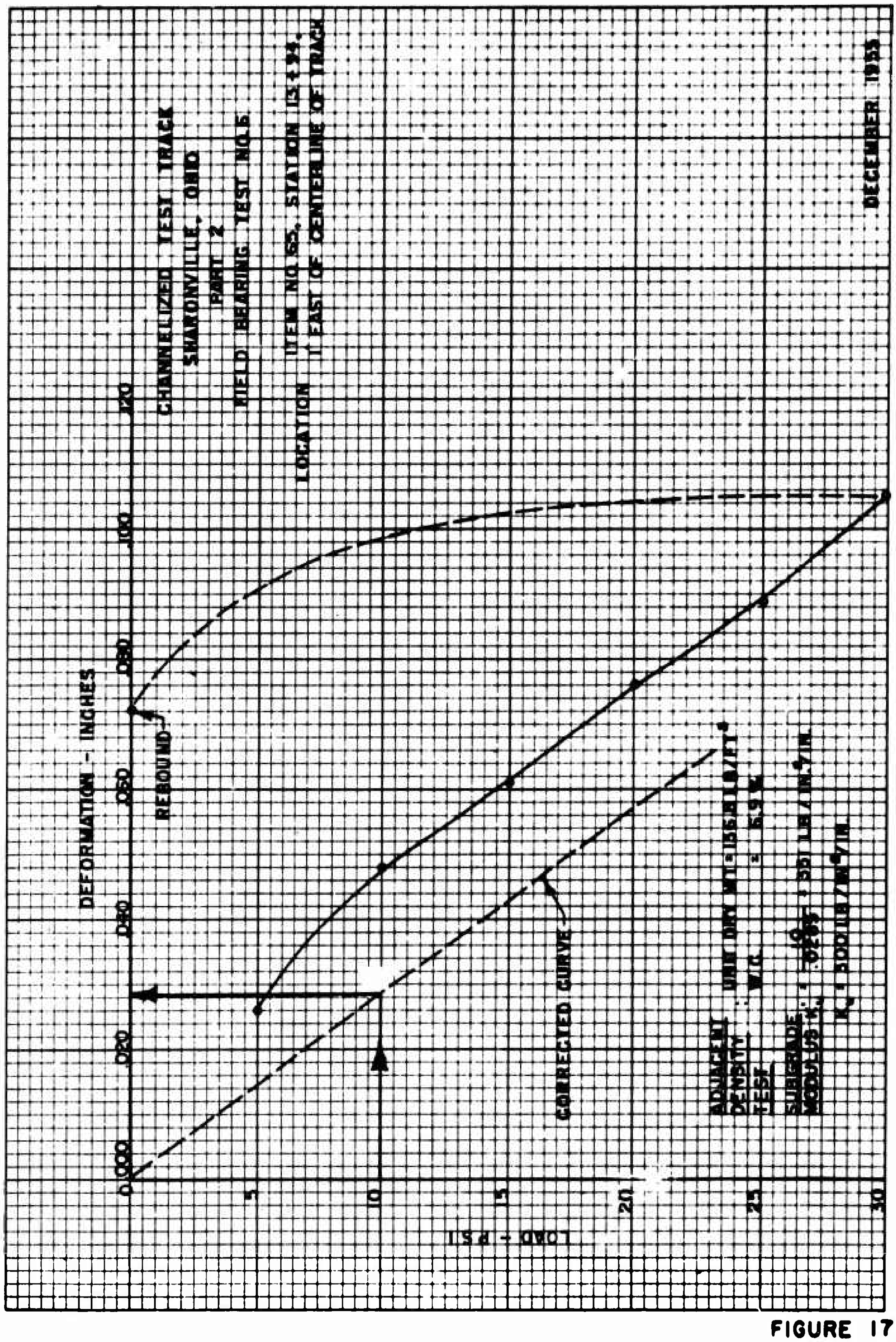

DEFORMATION - INCHES
0.000
.020
.040
.060
.080
.100
.120
REBOUND
CORRECTED CURVE
LOAD - PSI
0
5
10
15
20
25
30
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO. 5
ITEM NO. 165, STATION 13+94
LOCATION 1' EAST OF CENTERLINE OF TRACK
ADJACENT DENSITY TEST
UNIT DRY WT = 136.8 LB/FT³
W.C. = 5.9%
SUBGRADE MODULUS K = 10/.0285 = 351 LB/IN²/IN
K = 500 LB/IN²/IN
DECEMBER 1953

FIGURE 17

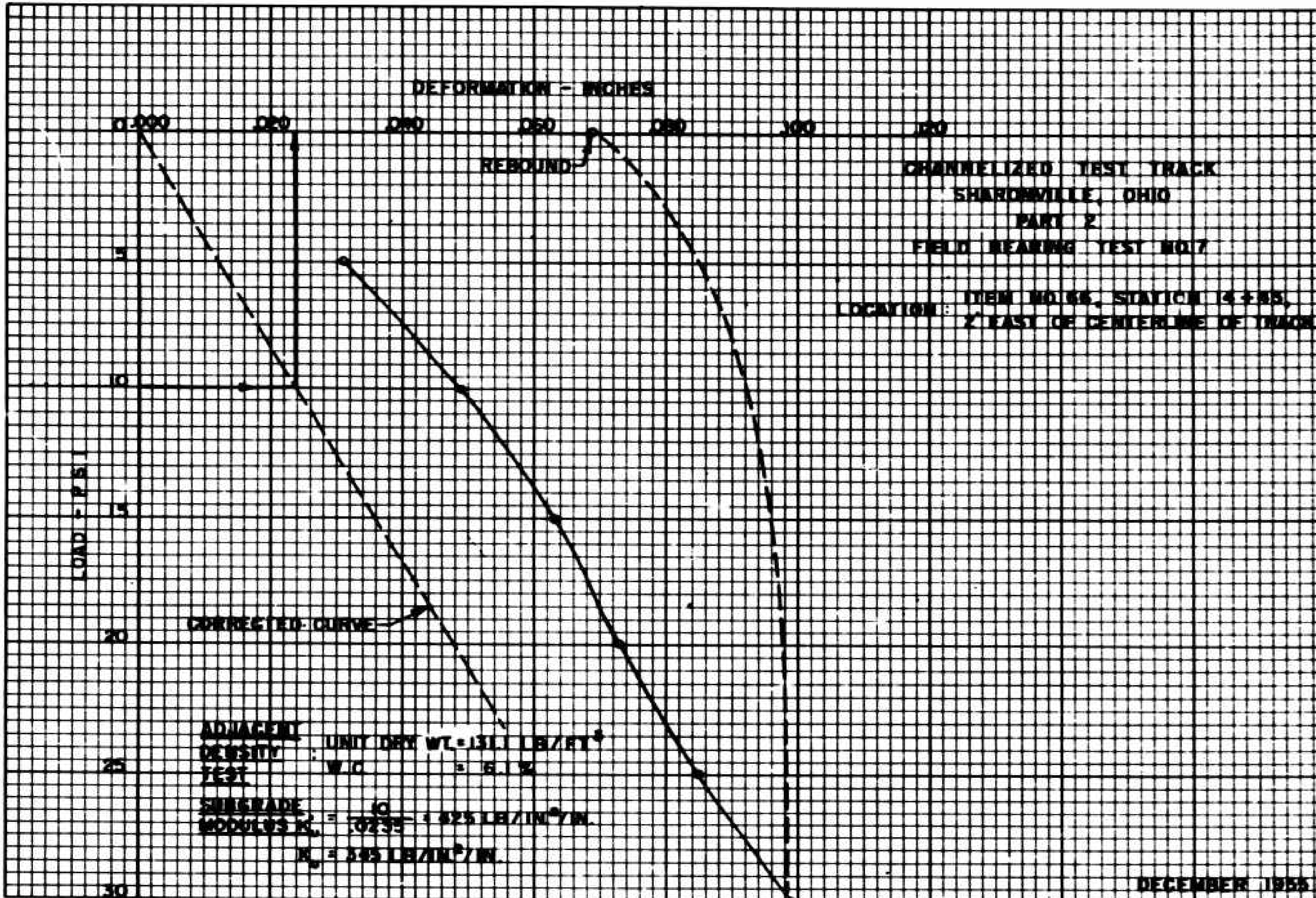

DEFORMATION - INCHES
0 .000
.020
.040
.060
.080
.100
.120
REBOUND
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO.7
LOCATION : ITEM NO.66, STATION 14+85,
2' EAST OF CENTERLINE OF TRACK
LOAD - P.S.I.
5
10
15
20
25
30
CORRECTED CURVE
ADJACENT DENSITY TEST : UNIT DRY WT.=131.1 LB/FT³
W.C. = 6.1 %
SUBGRADE MODULUS K_u = 10/.0235 = 425 LB/IN²/IN.
K_u = 345 LB/IN²/IN.
DECEMBER 1955

FIGURE 18

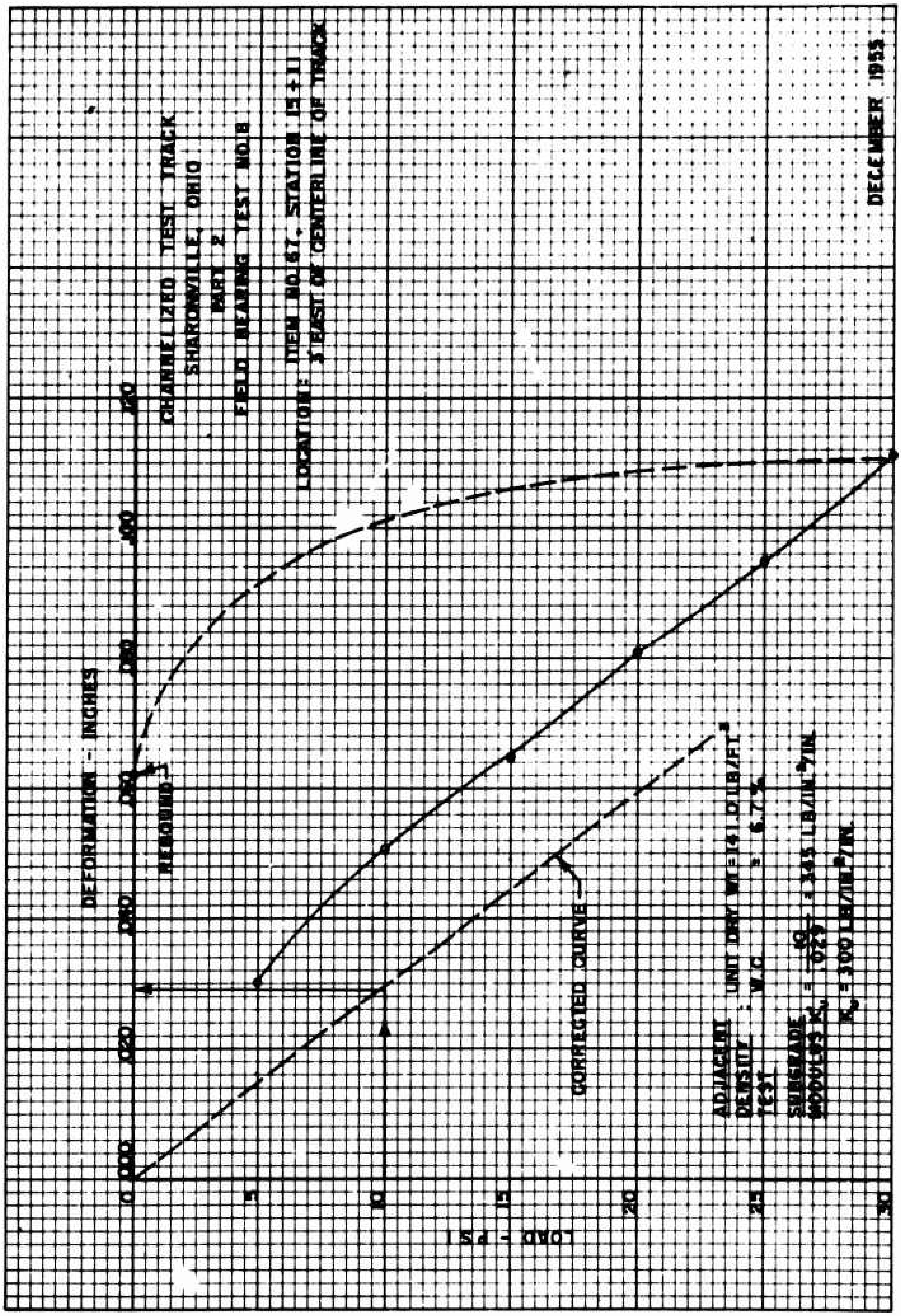

CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO.8
LOCATION: ITEM NO.67, STATION 15+11
5' EAST OF CENTERLINE OF TRACK
DECEMBER 1953
DEFORMATION - INCHES
0 .000
.020
.040
.060
.080
.100
.120
REBOUND
CORRECTED CURVE
LOAD - PSI
5
10
15
20
25
30
ADJACENT DENSITY TEST
UNIT DRY WT=141.0 LB/FT³
W.C = 6.7 %
SUBGRADE MODULUS K_u = 10/.029 = 345 LB/IN²/IN.
K_o = 300 LB/IN²/IN.

FIGURE 19

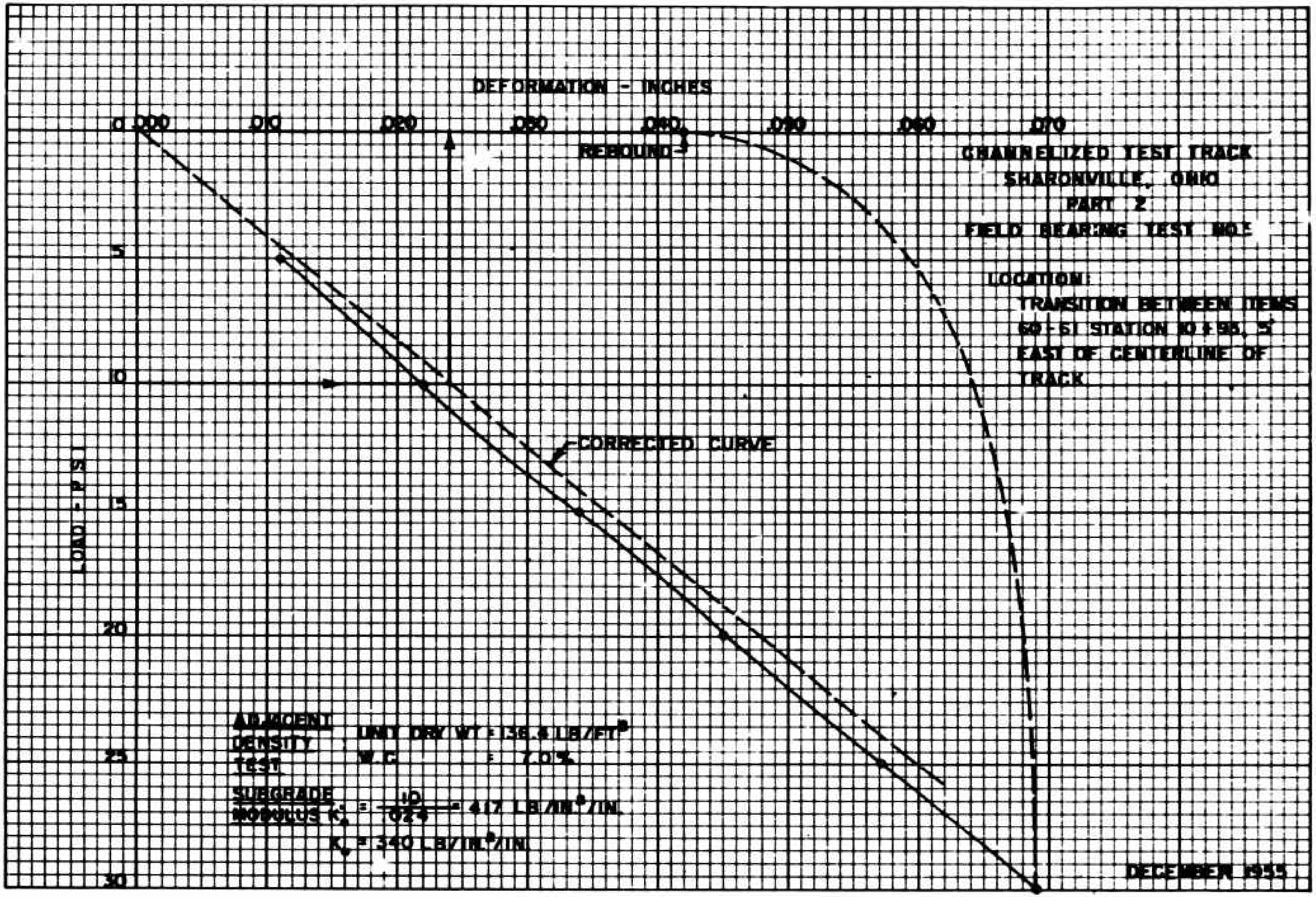
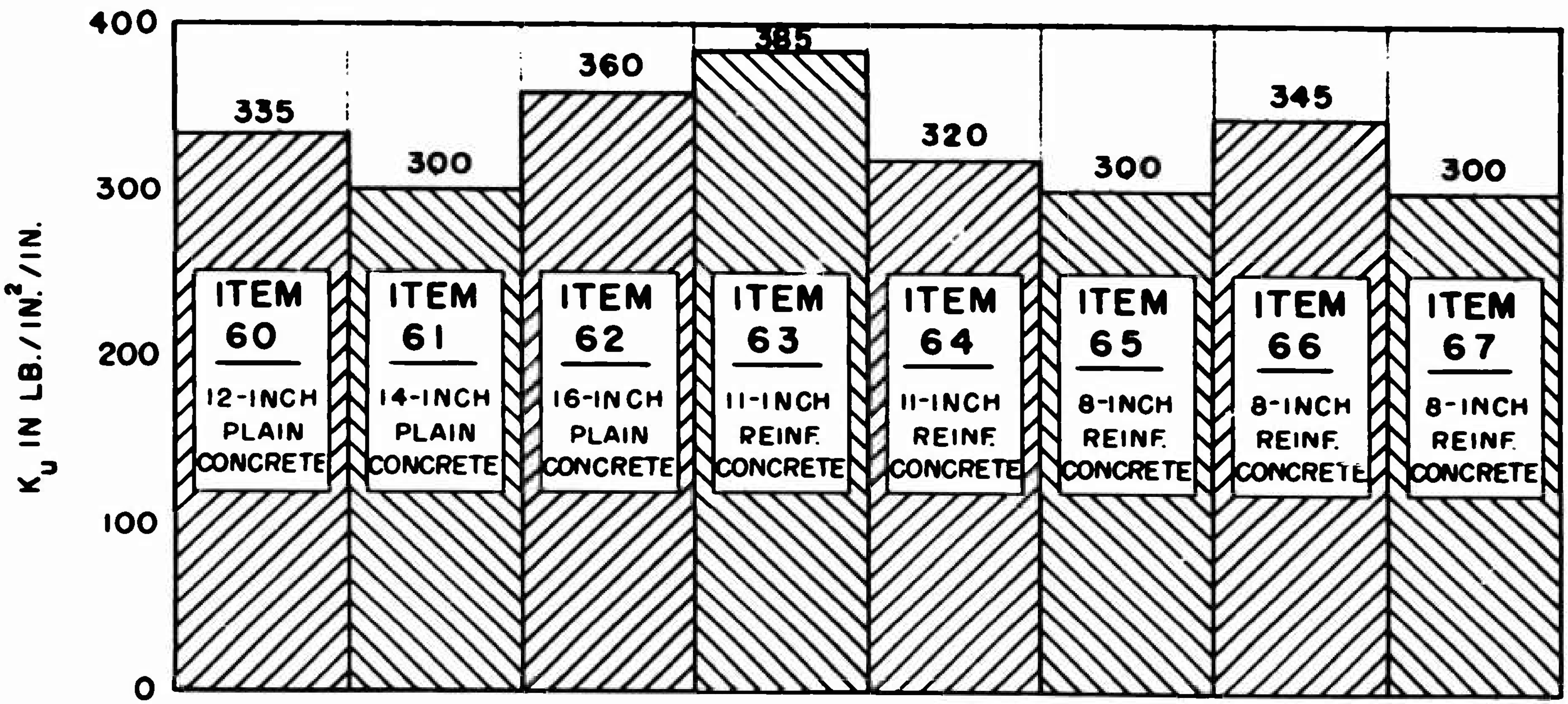

DEFORMATION - INCHES
0 .000
.010
.020
.030
.040
.050
.060
.070
REBOUND
LOAD - P S I
5
10
15
20
25
30
CORRECTED CURVE
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
FIELD BEARING TEST NO.
LOCATION:
TRANSITION BETWEEN ITEMS
60-61 STATION 10 + 95, 5'
EAST OF CENTERLINE OF
TRACK
ADJACENT DENSITY TEST
UNIT DRY WT = 136.4 LB/FT³
W.C. = 7.0%
SUBGRADE MODULUS K₁ = 10/.024 = 417 LB/IN²/IN
K = 340 LB/IN²/IN
DECEMBER 1955

FIGURE 20

CHANNELIZED TEST TRACK
SHARONVILLE, OHIO

PART 2
SUMMARY OF ESTABLISHED
SUBGRADE MODULUS VALUES



DECEMBER 1955

FIGURE 21

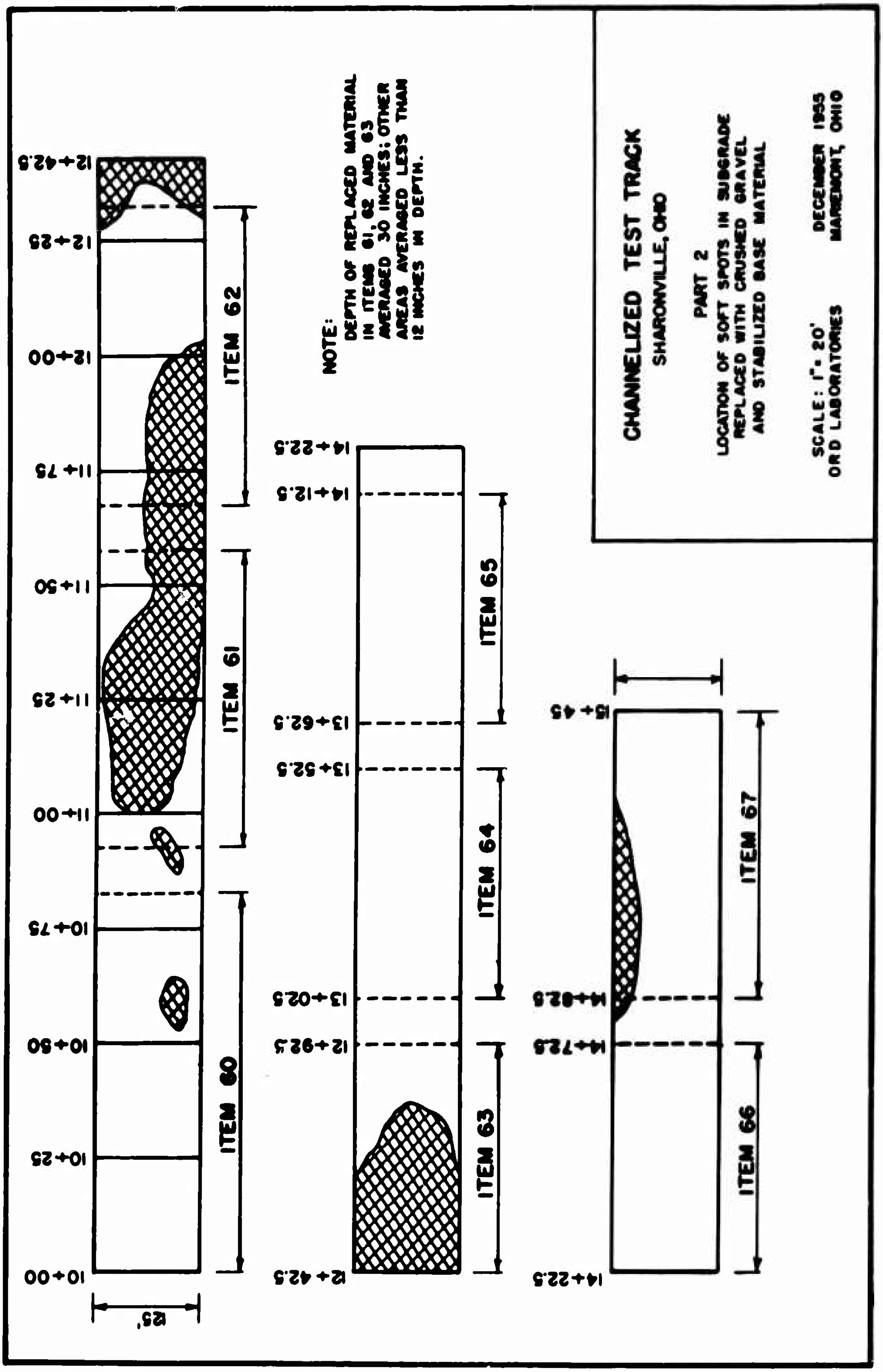
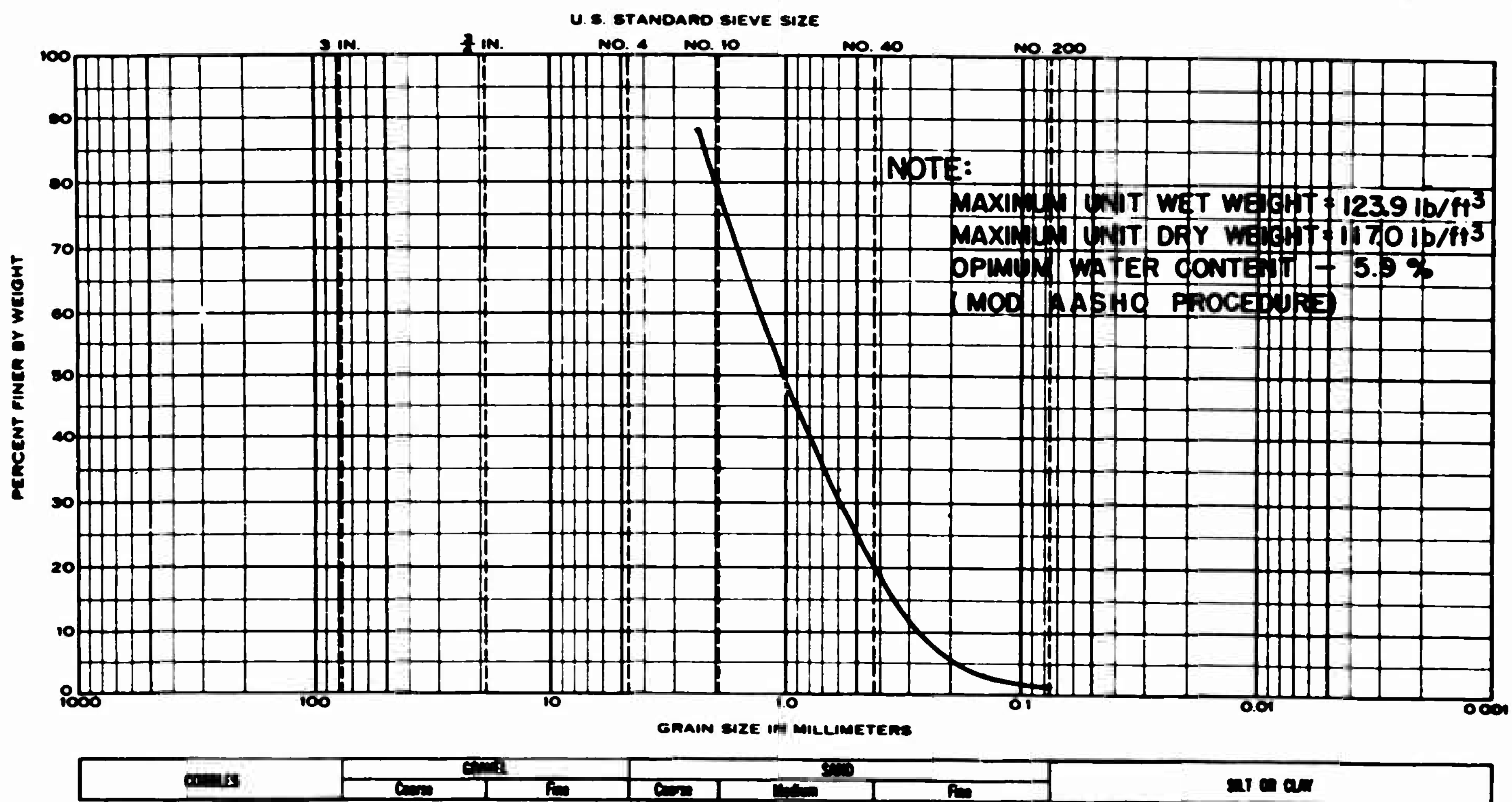

CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
LOCATION OF SOFT SPOTS IN SUBGRADE REPLACED WITH CRUSHED GRAVEL AND STABILIZED BASE MATERIAL
SCALE: 1" = 20'
DECEMBER 1955
ORD LABORATORIES
MARIEMONT, OHIO
NOTE:
DEPTH OF REPLACED MATERIAL IN ITEMS 61, 62 AND 63 AVERAGED 30 INCHES; OTHER AREAS AVERAGED LESS THAN 12 INCHES IN DEPTH.
12.5'
10+00
10+25
10+50
10+75
11+00
11+25
11+50
11+75
12+00
12+25
12+42.5
ITEM 60
ITEM 61
ITEM 62
12+42.5
12+92.5
13+02.5
13+52.5
13+62.5
14+12.5
14+22.5
ITEM 63
ITEM 64
ITEM 65
14+22.5
14+72.5
14+82.5
15+45
ITEM 66
ITEM 67

FIGURE 22



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI

GRADATION CURVES

Project CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
Area PART I
Boring No. FILTER MATERIAL USED UNDER ITEM 54
Date DECEMBER 1955

ENG FORM 2087

FIGURE 23

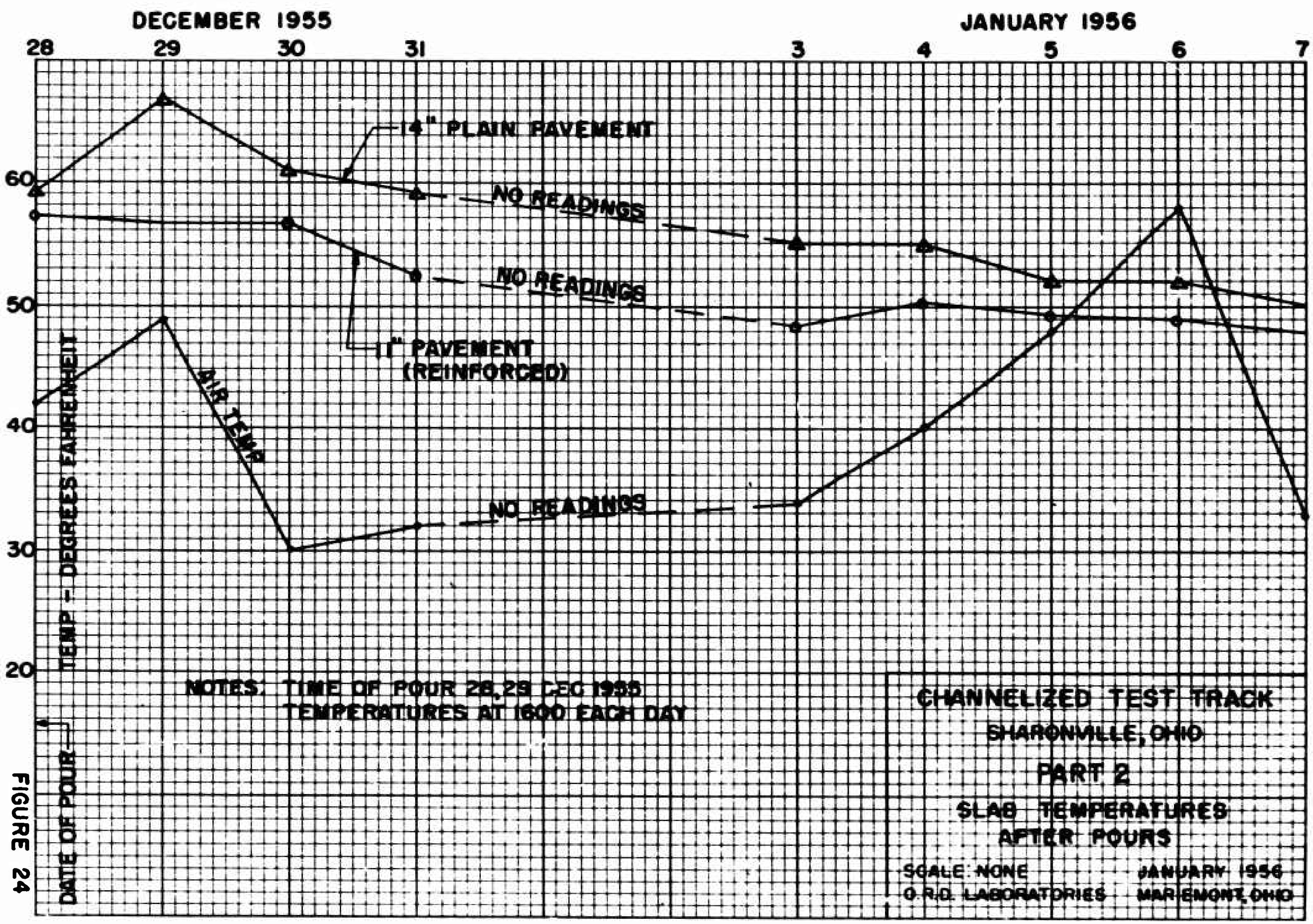
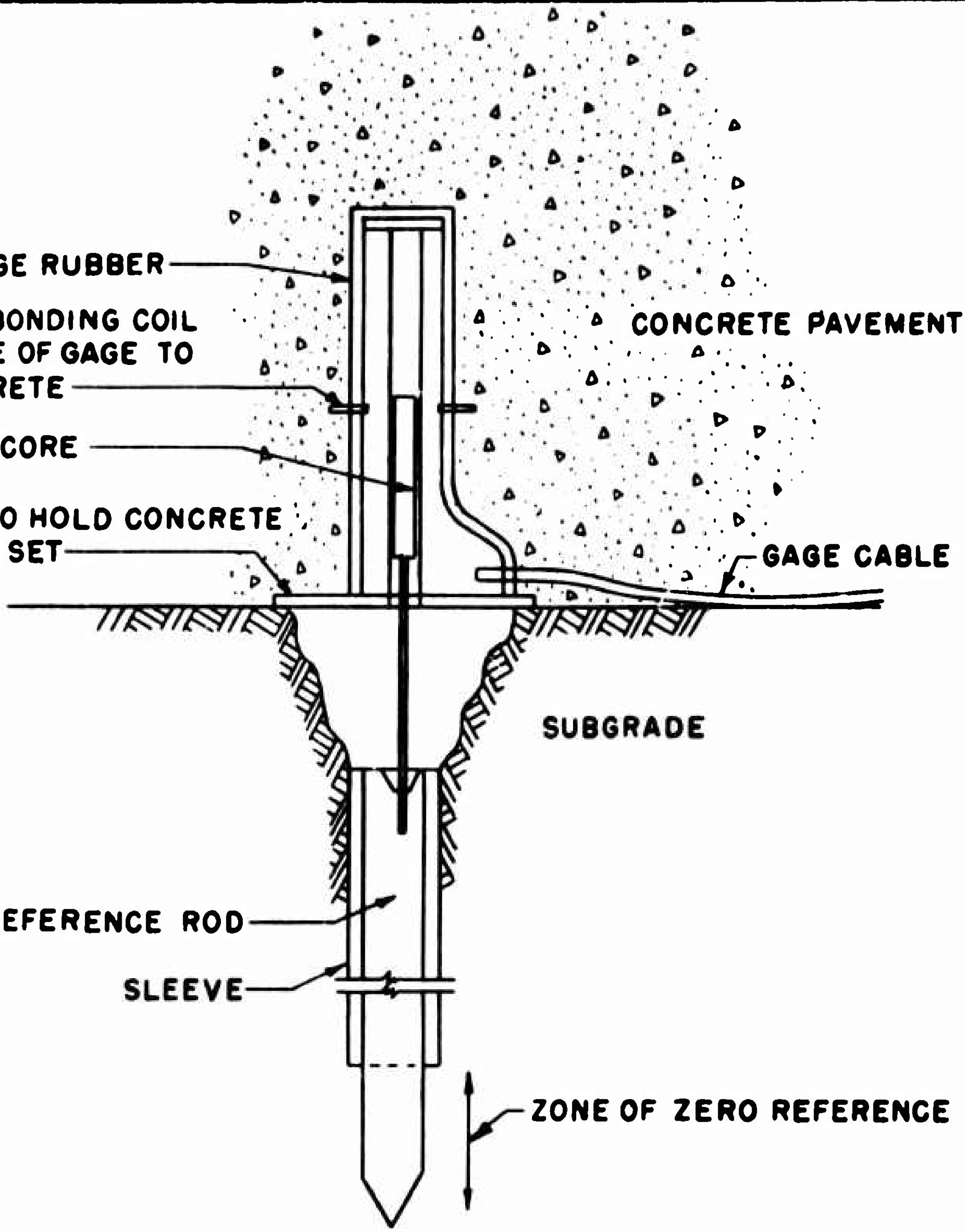

DECEMBER 1955
JANUARY 1956
28
29
30
31
3
4
5
6
7
60
50
40
30
20
TEMP - DEGREES FAHRENHEIT
DATE OF POUR
14" PLAIN PAVEMENT
11" PAVEMENT (REINFORCED)
AIR TEMP
NO READINGS
NO READINGS
NO READINGS
NOTES: TIME OF POUR 28,29 DEC 1955
TEMPERATURES AT 1600 EACH DAY
CHANNELIZED TEST TRACK
SHARONVILLE, OHIO
PART 2
SLAB TEMPERATURES
AFTER POURS
SCALE: NONE
JANUARY 1956
O.R.D. LABORATORIES
MARIEMONT, OHIO

FIGURE 24



CHANNELIZED TEST PROJECTS

TYPICAL DEFLECTION GAGE INSTALLED DURING CONSTRUCTION OF CONCRETE PAVEMENTS

SCALE: NONE OHIO RIVER DIVISION LABORATORIES	OCTOBER 1955 MARIEMONT, OHIO
DRAWN BY: CAAnderson TRACED BY: SHKuhn CHECKED BY: CAAnderson	FILE NO. VI-4-8-1

FIGURE 25

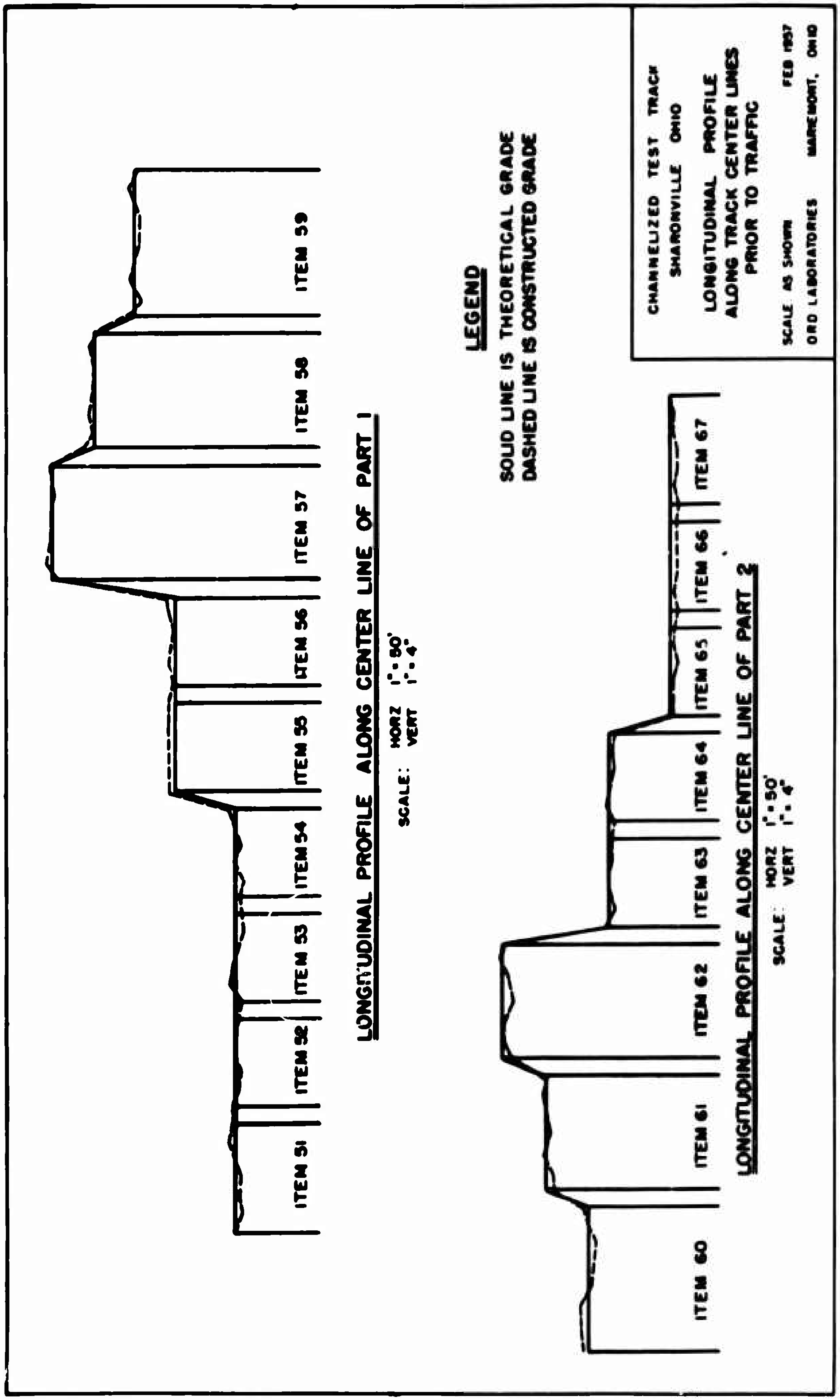

LONGITUDINAL PROFILE ALONG CENTER LINE OF PART 1
SCALE: HORZ 1" = 50' VERT 1" = 4'
ITEM 51
ITEM 52
ITEM 53
ITEM 54
ITEM 55
ITEM 56
ITEM 57
ITEM 58
ITEM 59
LEGEND
SOLID LINE IS THEORETICAL GRADE
DASHED LINE IS CONSTRUCTED GRADE
LONGITUDINAL PROFILE ALONG CENTER LINE OF PART 2
SCALE: HORZ 1" = 50' VERT 1" = 4'
ITEM 60
ITEM 61
ITEM 62
ITEM 63
ITEM 64
ITEM 65
ITEM 66
ITEM 67
CHANNELIZED TEST TRACK
SHARONVILLE OHIO
LONGITUDINAL PROFILE
ALONG TRACK CENTER LINES
PRIOR TO TRAFFIC
SCALE AS SHOWN
FEB 1957
ORD LABORATORIES
MARIEMONT, OHIO

FIGURE 26

Corps of Engineers U. S. Army

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

APPENDIX "A"

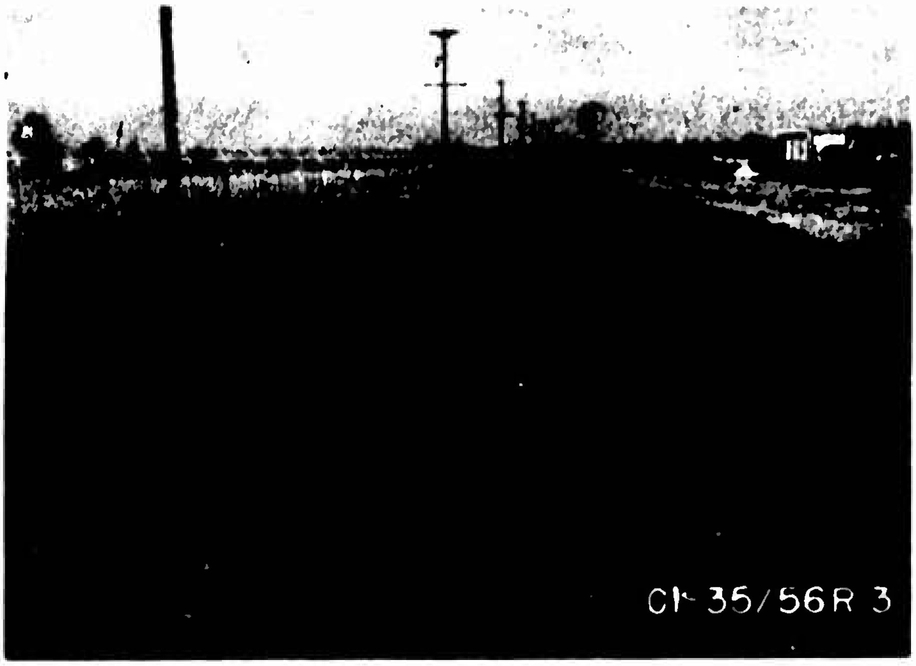
Representative Photographs
of
Construction

Ohio River Division Laboratories
Mariemont, Ohio

March 1957

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



Part 1 - Subgrade, Looking North

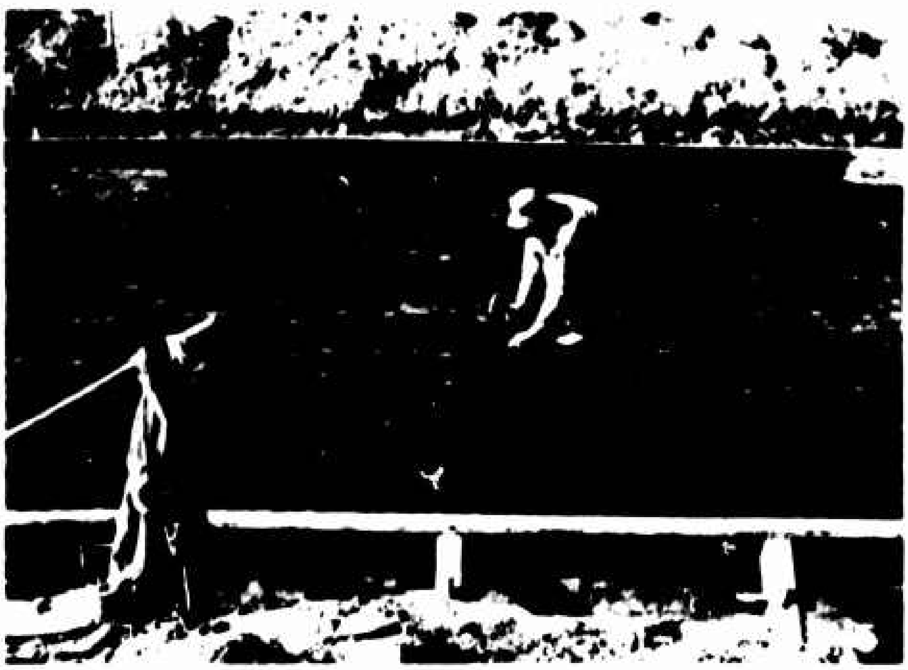
Part 2 - Subgrade, Looking North

PLATE 1

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

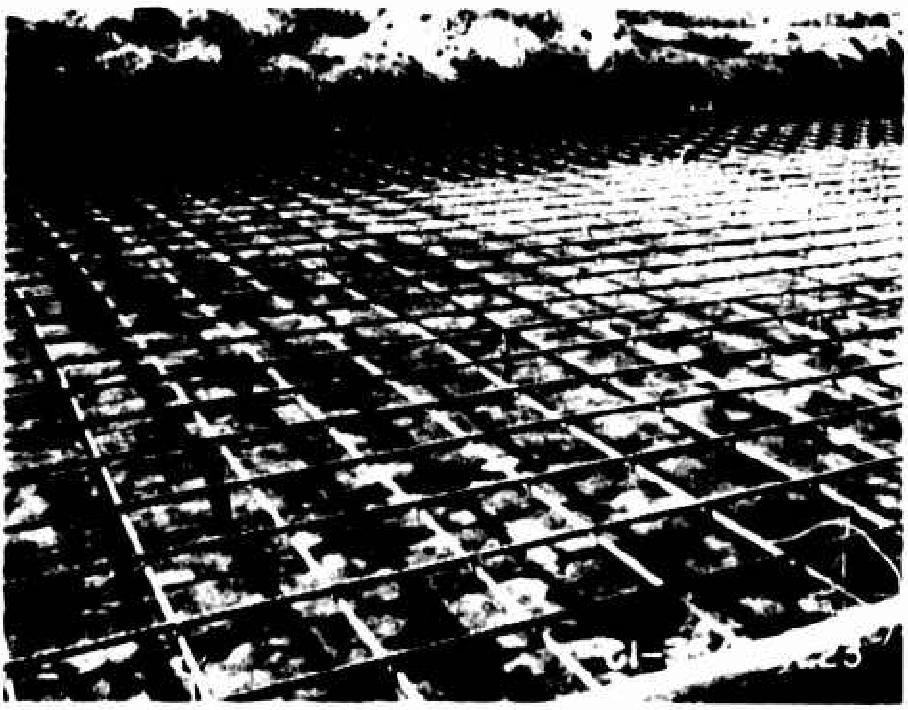
Grading Operations - Part 1



Placing Siselkraft Paper on Finished Subgrade - Part 1

PLATE 2

Driving Reference Rod for Deflection Gage Installation - Part 1



Reinforcing Steel in Place, Item 55 Part 1, #5 on 12-Inch Centers

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

Plastic Membrane and Deflection Gage
Item 59 - Prior to Concreting

Concreting Operations - Part 1
Item 59

PLATE 4

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

Tarrant Air Meter Being Used to Check
Entrained Air - Part 1

Field Beams for Laboratory Testing
Part 1

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

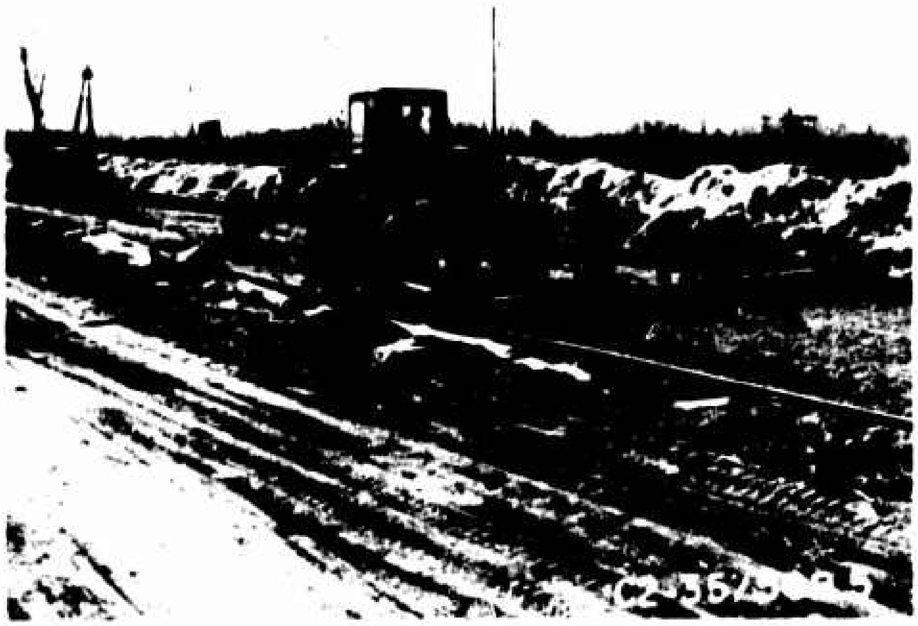
REPORT OF CONSTRUCTION

Concreting Operations, Part 1

Method of Protecting Concrete Against
Freezing Weather - Part 1

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



Grading Operations - Part 2

Grading Operations - Part 2

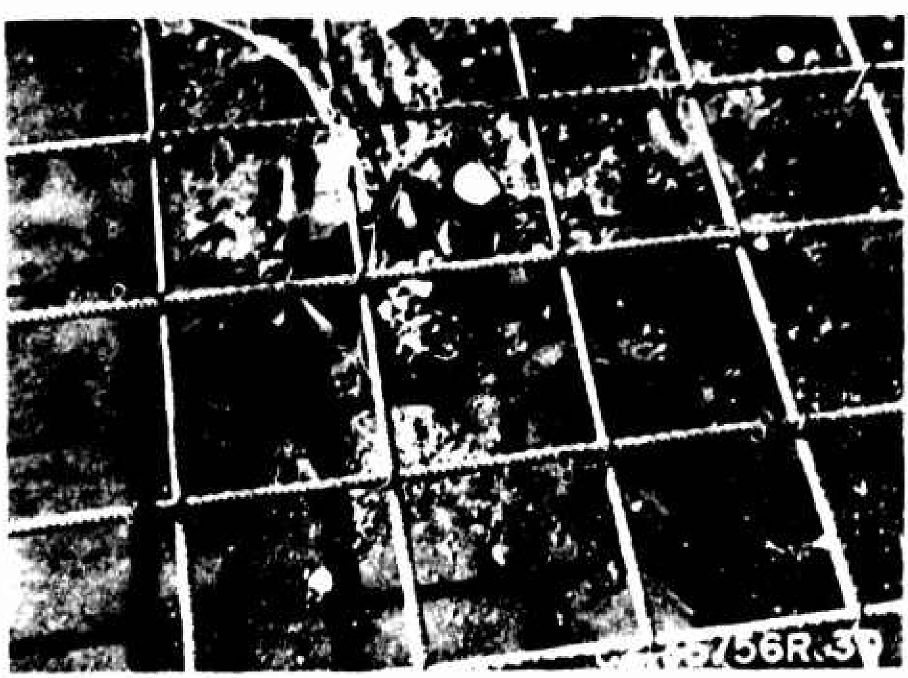
Checking Elevation of Forms - Part 2

Part 2 - Ready for Concreting at North End

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

Deflection Gage Installation in Reinforced Item - Part 2



Deflection Gage Installation in Reinforced Item - Part 2

PLATE 9

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION

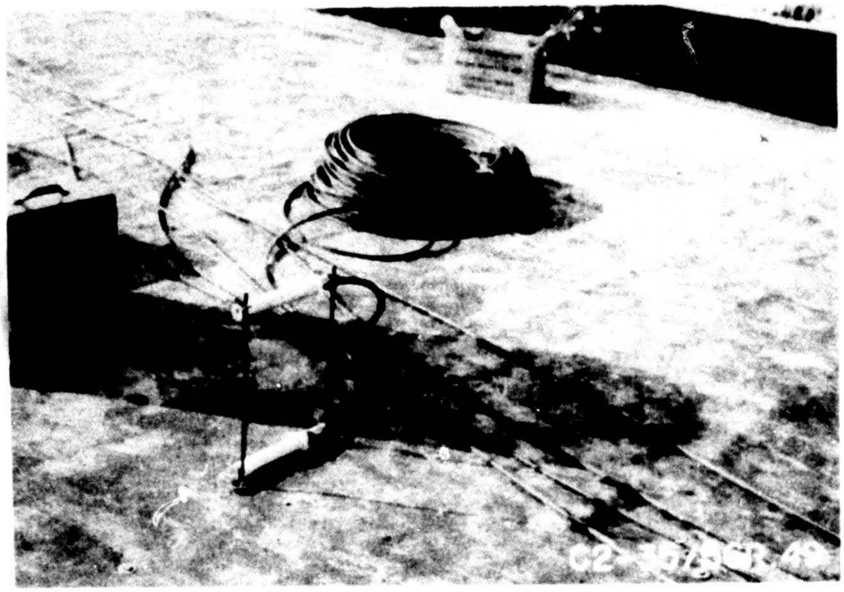
Concreting Operations - Part 2

Doweled Construction Joint @ Station 12 + 25 in Part 2

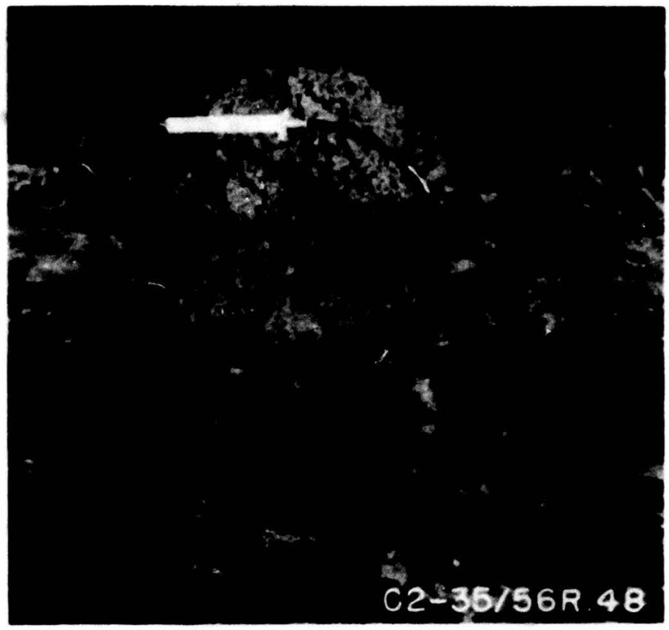
PLATE 10

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



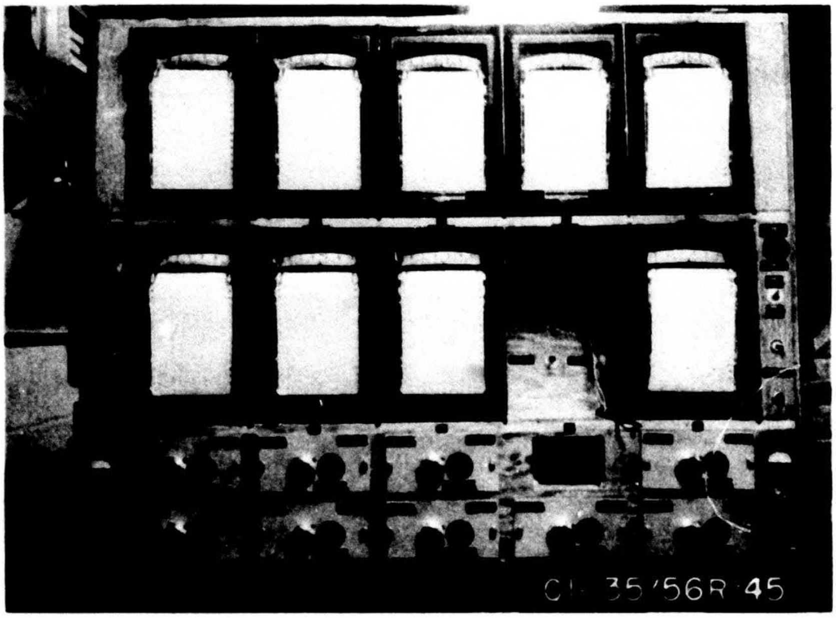
Carlson Strain Meter - Part 2



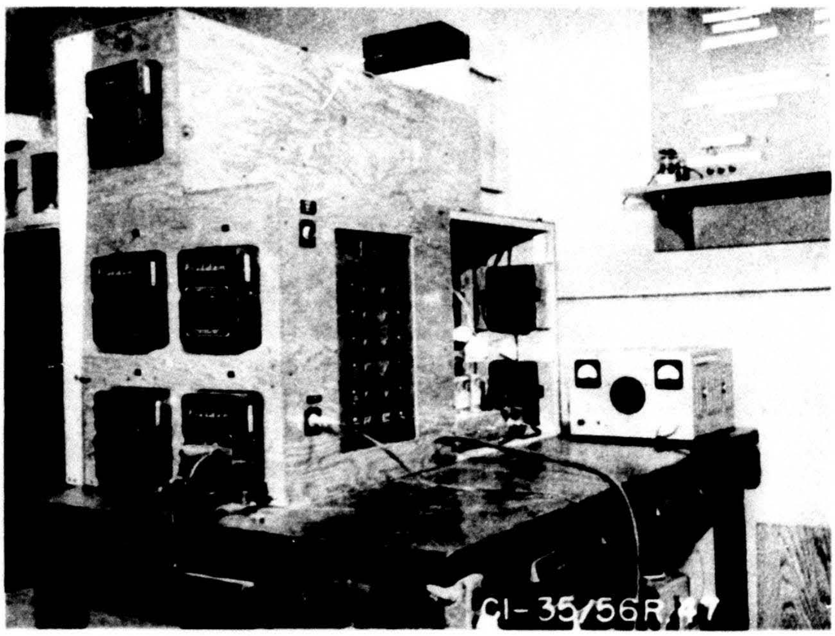
Carlson Strain Meter - Part 2

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



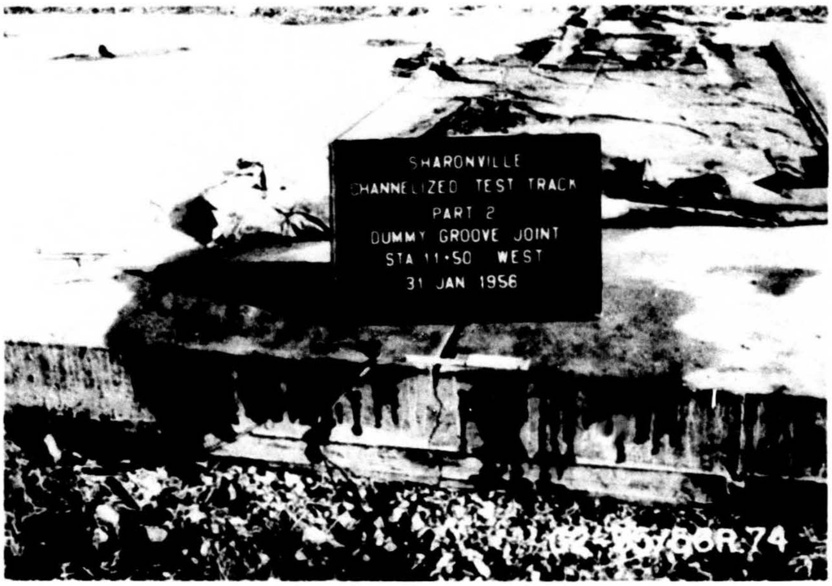
Front View of Instrument Panel for
Recording Strains and Deflections



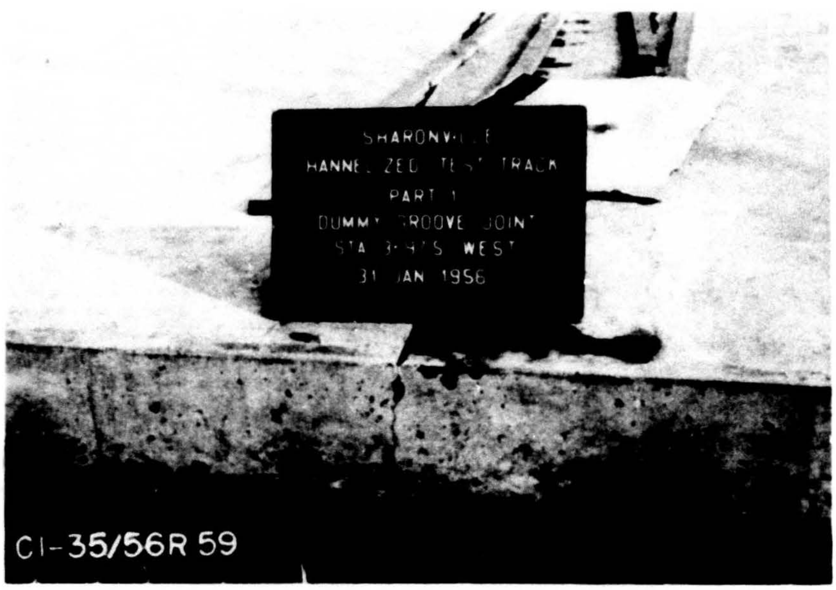
Rear View of Instrument Panel for
Recording Strains and Deflections

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



Controlled Cracking at Dummy Groove
Contraction Joint - Part 2



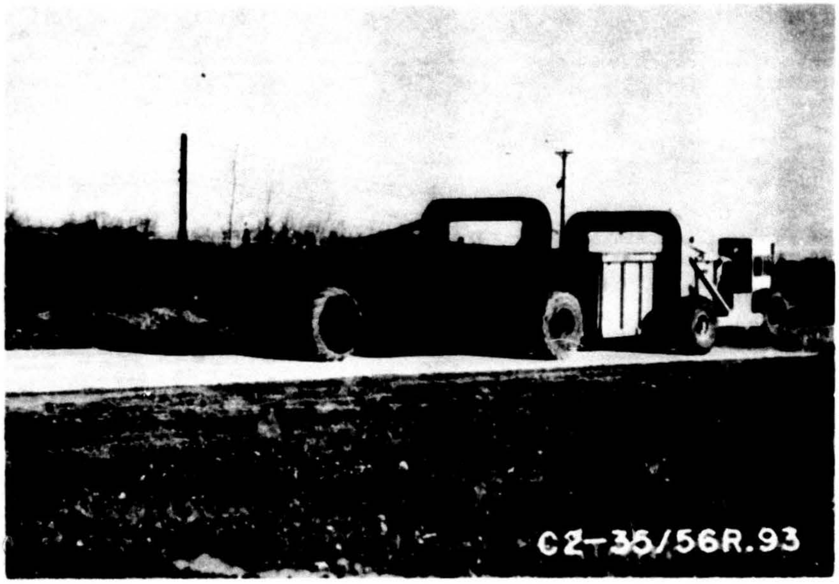
Controlled Cracking at Dummy Groove
Contraction Joint - Part 1

Part 1 - Ready for Traffic Looking North

Part 2 - Looking South from North End After 500 Coverages

CHANNELIZED TEST TRACKS
SHARONVILLE, OHIO

REPORT OF CONSTRUCTION



Applying Traffic with Double-Rig - Part 2